

DIETARY INTAKES OF AFRICANS IN TRANSITION IN THE NORTH WEST PROVINCE

Una Elizabeth MacIntyre, M.Sc. (Dietetics), RD

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Promoter: Prof. C.S. Venter

Co-promoter: Dr. N.S. Jansen van Rensburg

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**Potchefstroomse Universiteit
vir Christelike Hoër Onderwys**

To the memory of my parents

with love and gratitude

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ABSTRACT

The North West province of South Africa is experiencing a rapid influx of the predominantly African population from relatively underdeveloped rural to developed urban areas. Little is known of the effects of urbanisation on the dietary intakes and health status of the population. The objective of this study was to develop, evaluate and implement a culture sensitive quantitative food frequency questionnaire (QFFQ) and a food portion photograph book (FPPB) for the assessment of the dietary intakes of the African population of North West province as part of the Transition, Health and Urbanisation in South Africa (THUSA) project.

A preliminary study, using qualitative and quantitative research methods was undertaken among 32 female subjects representing rural(R), farm worker(F), informal settlement (IS), middle class urban (MCU) and upper class urban (UCU) strata. This information was used to develop a FPPB comprising near life-size, colour photographs of 37 foods. The FPPB was evaluated in a sample of 169 African subjects. The 145-item QFFQ was administered by trained Tswana speaking field workers. The reproducibility of the QFFQ was tested by repeat interviews on a sub sample of 144 THUSA volunteers. Relative validity was tested by comparison to intakes obtained from seven-day weighed food records of 74 THUSA subjects. Urinary nitrogen excretion was used to validate protein intake in 88 subjects. Completeness of the urinary collections was verified using *para*-amino benzoic acid (PABA). Basal metabolic rate (BMR) was used to estimate underreporting. Data was analysed as nutrient and food intakes. Data from the reproducibility and relative validation studies were analysed using Spearman rank correlation coefficients, paired t-tests, quintile distributions, the Bland-Altman technique and structural equation models (SEM). The QFFQ and FPPB were used to collect dietary information from 890 subjects from the above strata of urbanisation. Reported mean intakes and distributions were compared among strata.

Reproducibility was satisfactory for energy and macronutrients and was not affected by age, gender or stratum. The QFFQ tended to underestimate intakes compared to the weighed records. Quintile distributions were similar for both methods. A poor correlation was obtained between urinary nitrogen excretion and dietary intake. Validity coefficients using SEM ranged between 0,2 and 0,7. Possible underreporting was identified in 40% of the total sample but was not

affected by age, gender or stratum of urbanisation. Comparison of intakes between strata showed that maize was the staple food of the R, F, IS and MCU and met the prudent diet recommendations. Micronutrient intakes were low. The diet of the UCU showed a decrease in carbohydrate and increase in fat content and improved micronutrient intakes. There was a trend of movement away from a high carbohydrate, low fat diet in the R and F strata to a lower carbohydrate, higher fat diet associated with the chronic diseases of lifestyle in the urban strata. The QFFQ was found to be a reproducible, relatively valid, culture sensitive instrument for the assessment of the dietary intakes of the population of the North West province.

OPSOMMING

Die Noordwes-Provinsie van Suid-Afrika ondervind tans 'n vinnige toestroming van die oorheersend Afrikabevolking van relatief onderontwikkelde plattelandse na ontwikkelde stedelike gebiede. Min is bekend omtrent die effekte van verstedeliking op die dieetinnames en gesondheidstatus van die bevolking. Die doel van hierdie studie was om 'n kultuursensitiewe kwantitatiewe voedselrekwensievraelys (QFFQ) en 'n voedselporsiefotoboek (FPPB) te ontwikkel, evalueer en te implementeer vir die bepaling van dieetinnames van die Afrikabevolking van Noordwes-Provinsie as deel van die *Transition, Health and Urbanisation in South Africa* (THUSA)-projek.

'n Voorloperstudie, met gebruik van kwalitatiewe en kwantitatiewe navorsingsmetodes, is onderneem met 32 vroulike proefpersone verteenwoordigend van plattelandse (R), plaaswerker (F), informele woongebied (IS), middelklas stedelike (MCU) en gegoede klas stedelike (UCU) strata. Hierdie inligting is gebruik om 'n FPPB met naastenby lewensgrootte, kleurfoto's van 37 voedsels te ontwikkel. Die FPPB is in 'n steekproef van 169 Afrikaproefpersone geëvalueer. Die 145-item QFFQ is deur opgeleide Tswanasprekende veldwerkers geadministreer. Die herhaalbaarheid van die QFFQ is met herhaaldelike onderhoude in 'n substeekproef van 144 THUSA-vrywilligers getoets. Relatiewe geldigheid is getoets deur vergelyking met innames verkry met sewedag geweegde voedselrekords van 74 THUSA-proefpersone. Urinêre stikstofuitskeiding is gebruik om die proteïeninnames van 88 proefpersone te valideer. Volledigheid van urinêre versamelings is met behulp van *para*-aminobensoësuur (PABA) geverifieer. Basaalmetabolismespoed (BMR) is gebruik om onderrapportering te bepaal. Data is as nutriënt- en voedselinnames geanaliseer. Data van die herhaalbaarheid en relatiewe geldigheidstudies is geanaliseer met behulp van Spearman rangkorrelasiekoëffisiënte, gepaarde t-toetse, kwintiele verspreidings, die Bland-Altman tegniek en strukturele vergelykingsmodelle (SEM). Die QFFQ en FPPB is gebruik om dieetinligting te versamel van 890 proefpersone van die bogenoemde strata van verstedeliking. Gemiddelde

gerapporteerde innames en verspreidings tussen strata is met mekaar vergelyk.

Herhaalbaarheid was bevredigend vir energie en makronutriënte en is nie deur ouderdom, geslag of stratum geaffekteer nie. Die QFFQ was geneig om innames in vergelyking met die geweegde rekords te onderskat. Kwintiele verspreidings was soortgelyk vir beide metodes. 'n Swak korrelasie tussen urinêre stikstofuitskeiding en dieetinname is verkry. Geldigheidskoëffisiënte met behulp van SEM het van 0,2 tot 0,7 gewissel. Moontlike onderrapportering is in 40% van die totale monster geïdentifiseer maar is nie deur ouderdom, geslag of stratum van verstedeliking geaffekteer nie. Vergelyking van innames tussen strata het getoon dat mielies die stapelvoedsel van die R, F, IS en MCU was en aan die omsigtige dieetaanbevelings voldoen het. Mikronutriëntinnames was laag. Die dieet van die UCU het 'n afname in koolhidrate en toename in vetinhoud en verbeterde mikronutriëntinnames getoon. Daar was 'n neiging tot 'n wegbeweging van 'n hoë koolhidraat-, lae vetdieet in die R en F strata na 'n laer koolhidraat-, hoër vetdieet geassosieer met die chroniese lewenstylsiektes in die stedelike strata. Die QFFQ was 'n herhaalbare, relatief geldige, kultuursensitiewe instrument vir die bepaling van die dieetinames van die bevolking van die Noordwes-Provinsie.

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ABBREVIATIONS

AHA	American Heart Association
AP	As purchased
BMI	Body mass index
BMR	Basal metabolic rate
CI	Confidence interval
CV	Coefficient of variation
DLW	Doubly labelled water
EI	Energy intake
EP	Edible portion
F	Farm worker stratum of urbanisation
FFQ	Food frequency questionnaire
FPPB	Food portion photograph book
IA	Interviewer administered (food frequency questionnaire or diet history)
IS	Informal settlement stratum of urbanisation
IS	Interview schedule
MCU	Middle class urban stratum of urbanisation
N	Nitrogen
NI	Dietary nitrogen intake
NCD	Non-communicable disease
NRPNI	National Research Programme for Nutritional Intervention
PABA	<i>Para</i> - amino benzoic acid
PAL	Physical activity level
PSMA	Portion size measurement aid
PU for CHE	Potchefstroom University for Christian Higher Education
QFFQ	Quantitative food frequency questionnaire
R	Rural stratum of urbanisation
RDA	Recommended Dietary Allowances
SA	Self administered (food frequency questionnaire or diet history)
SD	Standard deviation
SEM	Structural equation model

SFFQ	Semiquantitative food frequency questionnaire
sd	Standard deviation of differences
sm	Standard deviation of means
TEE	Total energy expenditure
THUSA	Transition, health and urbanisation in South Africa project
UCU	Upper class urban stratum of urbanisation
UN	Urinary nitrogen
WR	Weighed record

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE PROBLEM: GLOBAL PERSPECTIVE

In the last several decades, developing countries have undergone marked demographic shifts from rural to urban. It has been estimated that by the year 2000, 50% of the world's population will live in urban areas, and within the next century most of the world's population will be urbanised (Gelderblom & Kok, 1994; Solomons & Gross, 1995). South Africa, as a semideveloped country and as the result of recent political changes, is experiencing a rapid and increasing influx of predominantly African people from the relatively underdeveloped rural areas to the highly developed and industrialised urban areas (Gelderblom & Kok, 1994).

The process of urbanisation is accompanied by changes in lifestyle, including dietary and activity patterns from traditional to those typical of urban societies. On the one hand, improved socioeconomic conditions and the availability of a wide variety of foods results in the increase in the incidence of obesity related and degenerative diseases, also known as non-communicable diseases (NCD's) or the chronic diseases of lifestyle, in developing countries previously free of these conditions (Popkin *et al.*, 1993). These diseases include coronary heart disease (Steyn *et al.*, 1991), hypertension (Opie, 1995), stroke (Seedat *et al.*, 1982) and non-insulin dependant diabetes mellitus (Levitt & Mollentze, 1995). On the other hand, beneficial effects such as a lowering of infant mortality rates, longer life expectancy and improved quality of life have been reported (Kutty, 1989; Jiménez, 1993; Shi, 1993). At the same time, there are many marginalised and destitute people who have remained in the rural areas or who live in the overcrowded informal settlements and towns (Solomons & Gross, 1995; Gelderblom & Kok, 1994). This results in the contradictory situation of over nutrition and under nutrition existing simultaneously (Popkin *et al.*, 1992; Peltó & Vargas, 1992).

There is agreement in the literature that the increase in NCD's in developing countries is associated with the demographic and epidemiologic transitions which occur during urbanisation (Omram, 1971; Popkin, 1994). Very little is known, however, about the risk factors for

developing NCD's in Africans in rural and urban areas or how these factors are influenced by economic development and acculturation. The challenge for nutritionists and health workers in South Africa is to move from a situation of under nutrition to optimal, not over nutrition. This will only be accomplished if the health status and food related behaviours of the population groups in the various stages of urbanisation are known and preventive measures are included in community health programmes and health facility-based services.

1.2 BACKGROUND TO THE PROBLEM: THE LOCAL SETTING

According to the 1996 census, the population of the North West province of three million represents approximately eight percent of the total South African population (37,9 million), while in terms of area, it comprises almost 10% of South Africa (Central Statistics, 1997). By far the majority of the population (65%) live in non-urban areas (Central Statistics, 1997). In comparison, 45% of the whole South African population is non-urban (Central Statistics, 1997).

The province falls almost entirely within the Savannah Biome (bushveld) with the exception of areas in the south which form part of the Grassland Biome. The climate of the province varies from almost subtropical in the central and southern parts to semi-desert in the western regions. It is a summer rainfall region with violent thunderstorms. The province has a strong agricultural base, with maize and sunflower being the most important crops. The areas around Rustenberg and Brits are mixed-crop fertile lands where crops such as tobacco, citrus and peppers are cultivated. The province is also known for its cattle farming. Diamond, gold and platinum mining play a dominant role in the economy of the province, contributing approximately 55% of its gross product and employing a quarter of the labour force. Nevertheless, low employment levels contribute to a high level of poverty (Jansen van Rensburg, 1995). Lack of a coherent development strategy in the past has resulted in strong contrasts between the highly developed, sophisticated urban areas such as the capital, Mmabatho and the largely under developed rural and semi-urban areas.

The North West province typifies the situation described for many developing countries with extremes of affluent and under developed populations, and a continuum of stages of transition in between. The Transition, Health and Urbanisation in South Africa (THUSA) project was initiated to identify and describe the possible risk factors of NCD's in rural and urban Africans in order to

provide information for the development of appropriate preventive strategies. The dietary intake assessment formed part of this study.

1.3 PURPOSE OF THE STUDY

In order to describe the effects of urbanisation on nutritional status it is necessary to collect valid and reliable data on eating patterns and nutrient intakes. Although there are a number of ways in which dietary intake data can be collected, there is no ideal instrument, and most instruments in use have been developed for urbanised, literate populations (Thompson & Byers, 1994). In addition to the instrument itself, suitable visual aids to assist respondents in describing foods and portion sizes are needed. Aids are usually actual foods and containers, food models of various kinds and pictures and photographs (Pietinen *et al.*, 1988a; Thompson & Byers, 1994). Actual foods and containers are cumbersome and often impractical to use, food models are expensive, and not always appropriate and existing pictures do not include local foods in appropriate portion sizes. A dietary intake measurement instrument together with visual aids, sensitive to the specific characteristics of the population under study and which provides reproducible and valid information therefore needs to be developed (Buzzard & Sievert, 1994; Cassidy, 1994; Hankin & Wilkins, 1994).

The development of a dietary intake assessment measurement instrument includes the testing of its reproducibility and relative validity in the target population. In the past, weighed food intake records have been used as the 'gold standard' against which other instruments have been measured (Willett, 1990). The weighed record, however, is itself subject to error (Burema *et al.*, 1995). This fact has stimulated interest in the use of biomarkers, especially urinary nitrogen excretion and energy expenditure as independent markers of dietary intakes (Bingham, 1991). Also, new approaches to the statistical analyses of reproducibility and relative validity data have been tested in an attempt to improve the rigour of the results (Beaton, 1991; Kaaks *et al.*, 1994b). To date, no stringent procedures for the testing of reproducibility and validity have been applied to the development of dietary intake assessment instruments for use in African populations. The purpose of this study was, therefore, not only to develop a quantitative food frequency questionnaire appropriate for use among the African population of the North West province, but also to test its reproducibility and relative validity using a combination of reference methods,

biomarkers and statistical techniques.

1.4 OBJECTIVES

1.4.1 Overall aim

The primary purpose of this study was to develop, evaluate and implement a culture-sensitive quantitative food frequency questionnaire together with appropriate visual aids for the collection of dietary information of the African population of the North West province of South Africa.

1.4.2 Specific aims

- 1.4.2.1 To develop a quantitative food frequency questionnaire (QFFQ) together with appropriate visual aids in the form of a food portion photograph book (FPPB) which was sensitive to the culture of the African population of the North West province. In order to achieve this aim, a preliminary study to describe the food habits of the North West province was necessary.
- 1.4.2.2 To test the reproducibility by administering the QFFQ to the same subjects on two occasions and comparing the data obtained on nutrient and food intakes.
- 1.4.2.3 To determine the relative validity of the QFFQ by comparison of the nutrient and food intake data derived from the QFFQ with those obtained from seven-day weighed food records.
- 1.4.2.4 To validate the QFFQ by comparison of the results of the nutrient analyses from the QFFQ with anthropometric and biochemical markers (basal metabolic rate and urinary nitrogen).
- 1.4.2.5 To improve the rigour of the results of the reproducibility and relative validation studies by the application of recently proposed statistical techniques (Bland & Altman, 1986; Beaton, 1991; Kaaks *et al.*, 1994b) to the data.

- 1.4.2.6 To use the QFFQ and FPPB to collect dietary intake data from five strata of urbanisation within the North West province in order to identify the changes in nutrient intakes occurring during urbanisation and to compare intakes with those of other population groups.

1.5 DELIMITATIONS

- 1.5.1 This study was concerned with the development, evaluation and use of the QFFQ and FPPB and did not attempt to identify associations between dietary intakes and health status.
- 1.5.2 The nutrient analyses were based on the available South African food composition tables (Langenhoven *et al.*, 1991a). The study did not attempt to analyse foods not in these tables.
- 1.5.3 Due to the nature of the study, the samples were limited to volunteers. Thus, the sample may not have been truly representative of the total population.

1.6 DEFINITION OF TERMS

The following definitions apply to terms used in the context of this thesis.

1.6.1 Acculturation

Acculturation, in its broad sense, is used to refer to the process whereby one culture assumes the characteristics of another culture. In this thesis, the term acculturation applies specifically to the changes which occur in the dietary intake patterns of the African population of the North West province through contact with the white 'westernised' culture.

1.6.2 Urbanisation

The movement of the population from rural to urban areas and the lifestyle changes which accompany this process.

1.6.3 Culture

Culture refers to the shared ideas, beliefs, knowledge and practices which form the basis of the social interaction of a population. In this thesis, culture refers specifically to food related beliefs and behaviours.

1.6.4 Transition

Transition in its broad sense describes a change from one state to another. In this thesis, the term 'health' transition refers to a change in the epidemiologic and demographic patterns of population which accompanies urbanisation. The 'nutrition' transition refers to changes in the structure and composition of the diet, specifically from a diet high in unrefined carbohydrate and low in fat to one in which the fat and refined carbohydrate content is increased and unrefined carbohydrate decreased.

1.6.5 Rural area

A rural area is one which falls under the authority of a traditional tribal head.

1.7 IMPORTANCE OF THE STUDY

Three aspects of this study have important implications. First, not only will it provide a reliable and validated dietary intake questionnaire for use in the main study on urbanisation of the African population in the North West province, but also for the collection of dietary data in other surveys and for the evaluation of nutrition intervention programmes. In addition, the food portion photograph book could be used as an aid in education, in collecting diet information in clinical settings and for patient dietary counselling.

Second, the procedures used to test the reproducibility and relative validity of the questionnaire may provide a standard for future validation studies in South Africa.

Third, the results of the main dietary intake study will be used to design a set of focussed, practical dietary recommendations and health education programmes to improve the quality of life of the people of the North West province.

1.8 ORGANISATION OF THE REPORT

Each of the objectives of the present study constituted a study in its own right. Thus, the total study comprised several sub-studies. This report has been organised in such a way that each chapter deals with one aspect which forms a complete entity. In other words, each sub-study is presented with its objectives, methods, results, discussion and conclusion. The Literature Review (Chapter 2) and the Synopsis, Recommendations and Conclusions (Chapter 9) show how the various parts of the project are linked together.

Following the introductory chapter, a review of the literature is presented in Chapter 2. This chapter provides background information on the population of the North West province, the process of urbanisation and the theoretical basis for the development and testing of dietary intake assessment instruments.

Chapter 3 describes the preliminary study which was undertaken to obtain the necessary information for the development of the QFFQ and FPPB.

The development of the food portion photograph book is described in Chapter 4. This chapter includes a discussion of the evaluation of the food portion photograph book.

Chapter 5 sets out the procedures followed in the development of the (QFFQ) and explains the methods common to the reproducibility, relative validity and dietary intake studies.

The reproducibility study is discussed in Chapter 6.

Chapter 7 deals with the determination of the relative validity of the QFFQ, including the statistical procedures used.

The ultimate test of the usefulness of a dietary intake assessment method is its ability to assess dietary intakes under field conditions. Thus, the results of the dietary intake study are presented in Chapter 8.

Chapter 9 brings together the developmental, reproducibility and relative validity studies and discusses the results and implications in terms of the total dietary intake study and how it relates to the nutrition transition in the North West province.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The study of dietary intakes is complex, involving a large number of interacting factors. On the one hand, there are the factors which affect dietary intakes themselves, for example, environmental, economic, social and historical factors. On the other hand, there are the factors which influence the accuracy of the dietary information, such as the methods of data collection and analysis, the reliability and the validity of the data. The literature review will attempt to address both aspects of dietary intake studies.

In the first part, the broader issues affecting dietary intakes of the African population of the North West province will be examined. A brief historical overview, particularly with regard to urbanisation, will be given; the process of urbanisation and its effect on the food intake patterns and health status of the population will be discussed and dietary intakes of African populations described.

In the second part, dietary intake methodology will be discussed with particular emphasis on the development of culturally sensitive dietary intake instruments and the measurement of the reproducibility and relative validity of dietary intake measurement instruments. The study of dietary intakes in South Africa will also be described.

2.2 THE AFRICAN POPULATION OF THE NORTH WEST PROVINCE

2.2.1 Historical overview

The present population of the North West province (3,0 million) (Central Statistics, 1997), comprises approximately 63% Setswana, 14% isiXhosa and 8% Sesotho speakers (Janse van Rensburg, 1995). Thus, the history of the African population of North West Province can be described primarily as the history of the Sotho and Tswana people, who make up the majority of

the population. The Tswana, or Western Sotho, the Southern Sotho (Basotho) and the Northern Sotho together make up the Sotho people. This classification is based primarily on a common language base as well as certain shared practices (Maylam, 1986). For example, both groups lived in round huts with stone or earthen walls and conically shaped thatched roofs, organised into villages and were agro-pastorists and hunter-gatherers (Setiloane, 1976; Pistorius, 1994). The peoples who have inhabited the highveld plateau of the South African interior are thus referred to as the Sotho-Tswana in the literature as will be done in the present review (Lye, 1980a; Maylam, 1986; van der Wateren & Immelmann, 1988).

The knowledge of the origins of the Sotho-Tswana people is based primarily on oral tradition. According to legend, the Sotho and Tswana peoples originated from the bed of reeds at Ntswana-tstati ('Where the sun rises') (Lye, 1980a). It is probable that the ancestors of the present day Sotho-Tswana people migrated from the north in several migrations separated in time and from different stocks (van Warmelo, 1974) and dispossessed or absorbed the earlier San inhabitants of the area. The initial migrations have been placed in the thirteenth to fourteenth centuries or earlier (Lye, 1980a; van der Wateren & Immelmann, 1988). The early history of the Sotho-Tswana was characterised by the fission of chiefdoms into smaller groups and fusion with other groups (Lye, 1980a; van der Wateren & Immelmann, 1988). Despite frequent quarrels and splitting, the people appear to have prospered and spread over the North and North West provinces, Northern Cape, North West Free State and the Eastern region of Botswana (van Warmelo, 1974; Lye, 1980a; van der Wateren & Immelmann, 1988). By the beginning of the 19th century, when the first contact with white explorers was made by the Tlhaping (Schapera & Comaroff, 1991), the Sotho-Tswana was a well-established population (Setiloane, 1976) with complex and well developed social and political institutions (Cornwell, 1988). The Southern Sotho occupied the land south and east of the Vaal river and the Tswana the larger area in the north west (Lye, 1980a).

At the beginning of the nineteenth century, the warriors of the powerful Zulu nation in Natal moved northwards with devastating force, attacking and dispersing tribes in their path. The Sotho-Tswana were unprepared for this onslaught, being in fragmented chiefdoms without common leadership, such as in a confederacy, and occupying land difficult to defend (Cornwell, 1988). Refugees from the Zulu attacks, in turn, attacked their neighbours so setting up a chain

reaction of attack, counter attack and devastation which spread through the Free State to the Tswana in the region between the Orange and Vaal rivers and further to the North West. This period of unrest and war became known as the *Difaqane*, a Sotho word meaning the 'scattering' (Maylam, 1976; Lye, 1980a) and lasted for two decades from approximately 1812 to 1837 (van der Wateren & Immelman, 1988).

The effects of the *Difaqane* on the Tswana were devastating: the Sotho-Tswana peoples suffered continuously from invasions, many had to flee from their traditional lands, and they permanently lost their heartland, first to the Ndebele, and later to white settlers, who annexed it before the Tswana could return (Lye, 1980b). However, most chiefdoms survived by settling temporarily far from their homes, sometimes under the protection of the Griquas or white missionaries (Lye, 1980b; Maylam, 1986). The *Difaqane* possibly marked the first changes to the 'traditional' Sotho-Tswana life style that would increase in momentum with contact with Europeans and urbanisation.

The first missionary contact with the Tswana was in 1816 by the London Missionary Society among the Tlhaping (the southernmost tribe) (Lye, 1980b). During the next 30 years, most of the other tribes, apart from those in the far north, had contact with traders, explorers and hunters. Between 1820 and 1846 mission stations were established among several tribes including Rolong, Hurutshe, Kgatla and Kwena (Schapera & Comaroff, 1991).

In addition to contact with the missionaries, the Sotho-Tswana came into contact and conflict with the Voortrekkers who had trekked from the Cape and settled in the Transvaal. In 1852, the South African Republic was created by the amalgamation of several smaller states. The presence of the white farmers put further pressure on the Sotho-Tswana by reducing the amount of land available for agriculture and hunting. As the nineteenth century progressed, the Sotho-Tswana came into more and more contact with whites as well as being caught up in the political and economic movement of the time. By the end of the nineteenth century, the area originally occupied by the Sotho-Tswana had been divided among the Cape Colony in the South, Great Britain in the North and the South African Republic in the east. Reserves were established for the Tswana in the Transvaal, British Bechuanaland and the British Protectorate, but much of the land in these areas was already occupied by whites. The power of the chiefs was greatly

curtailed and the people had to pay taxes to the European governments. The agricultural base was eroded and replaced by increasing dependence on employment by whites for survival (Schapera & Comaroff, 1991). The combined effects of the *Difaqane* and the presence of white settlers were to scatter the Sotho-Tswana people throughout Southern Africa. However, the ancestral lands which survived the *Difaqane* and the settlement of whites have been maintained (Setiloane, 1976). Likewise, although the Sotho-Tswana culture has been changed by the incorporation of the white culture, much of the core culture has remained (Comaroff & Comaroff, 1991).

As a detailed account of the history of the African population of the North West province is beyond the scope of this review, the reader is referred to historical texts for in-depth discussions on the origins, history and interactions of the African population of the North West province (Cornwell, 1988; Comaroff & Comaroff, 1991; Maylam, 1986; Lye & Murray, 1980; Schapera & Comaroff, 1991).

2.2.2 Urbanisation

2.2.2.1 The urbanisation process

In the last several decades, developing countries have undergone marked demographic shifts of populations from rural to urban. It has been estimated that by the year 2000, approximately 50% of the world's population will live in urban areas, and within the next century most of the world's population will be urbanised (Gelderblom & Kok, 1994; Solomons & Gross, 1995; Yach *et al.*, 1995). South Africa, as a semideveloped country and as the result of recent political changes, is experiencing a rapid and increasing influx of predominantly African people from the relatively underdeveloped rural areas to the highly developed and industrialised urban areas (Gelderblom & Kok, 1994). In order to understand the effects of this movement on the health status of a population, it is first necessary to define the terminology used.

2.2.2.1.1

Rural and urban areas

In a discussion of urbanisation, it is important to clarify the meanings of the terms urban and rural. Definitions of urban vary from purely quantitative based on population density to definitions based on criteria such as type of administration, economic base and access to services (Yach *et al.*, 1995). The term 'rural' usually refers to an area of countryside where the inhabitants depend primarily on agriculture for their livelihood and which does not fall into a metropolitan area (Gelderblom & Kok, 1994). An urban area has been defined by Gelderblom and Kok (1994: 260) as an area

'... usually characterised by a concentration of people who depend predominantly on incomes derived from non-agricultural pursuits, and they usually contain certain services associated with town and/or cities ...'

Urbanisation is thus the increase in population in an urban area, due to the migration of people from rural areas (Gelderblom & Kok, 1994).

The above definitions put the process of urbanisation into a very simplistic light, that is, people live in either a rural area where they depend on the land for a living, or they live in a town or a city, where they derive their income from some form of employment. In reality, the process of urbanisation is complex and many settlement areas do not clearly meet the criteria of 'urban' or 'rural' but have characteristics of both. In the South African context, the situation is further complicated by past government policy which prevented the free movement of the African population. A discussion of these policies and their effect on urbanisation is beyond the scope of this thesis and the reader is referred to the works by Maylam (1986) and Gelderblom and Kok (1994). Nevertheless, the policies of the past not only had a profound effect on the African population but still have ramifications at present (Wisner, 1989). For this reason, a brief background to urbanisation will be given and the types of rural and urban settlements which developed within the political structure will be described.

Geographically demarcated reserves for Africans, known as 'homelands' were constitutionally defined within the borders of South Africa. These 'homelands' were intended to become

independent in terms of the later evolution of the policy of the then government. In order to encourage the African population to stay in the homelands, a policy of industrial decentralisation was followed from the 1960's. Industries were subsidised to decentralise or establish plants close to the borders of the homelands. This policy gave rise to a number of different settlement types which continue to exist (Gelderblom & Kok, 1994):

(a) Homeland urban:

These are proclaimed towns within the homeland areas. These settlements may also be classified as semi-urban, that is, having some of the characteristics of an urban town such as a municipal infrastructure, yet being far from a metropolitan area. Also, within the homeland borders were the so-called 'dormitory' or 'commuter' towns (May, 1989). These towns provided homes for commuters working in nearby urban centres but did not have their own economic base. These towns have been classified as peri-urban.

(b) Homeland fringe:

These were informal settlements situated on the homeland boundaries, close to the major urban centres to which the inhabitants commute for work. These settlements could be classified together with the above commuter towns as peri-urban.

(c) Closer settlements

These are settlements within the former homeland areas, which comprise concentrations of people who no longer have access to agricultural land but which also do not have an economic base. The inhabitants are largely dependant on the incomes of migrant labourers and pensions.

(d) Homeland rural

A striking characteristic of the African rural areas is that they cannot be regarded as 'rural' in the strict sense of the above definition as many of the people living in these areas are landless. Migrant labour and pensions are the primary sources of income.

The above factors describe a type of urbanisation in the non-urban areas of South Africa and may suggest that true urbanisation, that is the migration of people to the established urban areas was

not taking place. However, this is not the case. Despite measures to limit the number of Africans moving into urban areas, movement took place, forcing municipalities to establish living areas (so-called townships or locations) for the African populations. The establishment of these formal townships could not keep pace with growing number of migrants, resulting in the development of informal settlements on the periphery and within developed areas of the established towns, in much the same way as has occurred with urbanisation in other third world countries (May, 1989; Gelderblom & Kok, 1994).

2.2.2.1.2 *Migration*

Migration is a fundamental part of the urbanisation process. In South Africa, a large proportion of the economy utilises migrant labour, particularly the mining industry. A migrant labourer is one who is recruited in his home area and contracted to work, often hundreds of miles away from his home, only returning home occasionally (Moodie, 1991). The migrant labourer often provided the only source of income to his family in a closer settlement or rural area. The migrant labourer sees his situation as temporary, its prime purpose is to make money with which to support his family and his eventual aim is to settle back in his home area (Gelderblom & Kok, 1994).

Within the process of urbanisation, several forms of migration can be distinguished:

(a) Permanent migration:

This can be described as the once-off transfer of individuals from a rural to an urban environment (Gelderblom & Kok, 1994). Permanent migration is also referred to as stabilisation and can be expressed quantitatively as a ratio of the years spent in an urban area to an individual's age (Dubb, 1974). However, permanent migration does not necessarily mean that the individual has cut all ties with his area of origin. He may still visit and have contact with rural relatives from time to time (Gelderblom & Kok, 1994).

(b) Circular migration:

This is migration of an oscillating nature, that is, the migrant returns to his place of origin. Return migration occurs when only one cycle is completed during the migrant's

life time, usually when he returns to his home area on retirement. This implies a period of relatively permanent settlement in the urban area. Circulation refers to the constant movement of the migrant between his home area and his work area and does not include permanent settlement away from his place of origin (Gelderblom & Kok, 1994).

In the past, movement to and from urban and rural areas followed the 'push-pull' dynamic (May 1989). Factors such as loss of agricultural land, few cash generating opportunities and poverty acted to 'push' migrants from the rural to the urban areas. Other factors, particularly the need for family unity and obligations in the rural areas served to 'pull' the migrant back to his rural home. More recently, increasing poverty and deterioration in rural areas have weakened the 'pull' while the cost of living in urban and peri-urban has decreased. This has resulted in a change in the urbanisation process in South Africa, from that of circular to more permanent settlement in urban and especially peri-urban areas (May, 1989).

2.2.2.2 Consequences of urbanisation

The literature on the effects of urbanisation on the health status of populations sometimes appears to give conflicting messages. On the one hand, a positive message of improved health status as measured by declining infant mortality rates, reductions in infectious diseases and longer life expectancies is given (Walker, 1996). On the other hand, some authors paint a picture of increased infant and childhood mortality, high incidences of contagious diseases and malnutrition and high mortality (Byarugaba, 1991; Harpham & Stephens, 1991; Bockerhoff, 1995). The reason for this apparent contradiction lies in the different approaches taken to the process of urbanisation. In the first instance, urbanisation is looked at in a broad long term perspective which will show overall benefit for the total population. The second view is more short term, looking at the immediate effects of migration and rapid urbanisation on an individual or a community within a population. The two processes in fact occur together resulting in situations, for example in the case of nutritional status, where over and undernutrition exist side by side (Harpham & Stevens, 1991; Popkin, 1994; Verheij, 1991). In a country such as South Africa, the differences in health status among populations is pronounced, but at the same time there are differences within populations.

Urbanisation in developing countries has generally occurred independently of growth in prosperity

through industrialisation (in contrast to developed countries) (Yach *et al.*, 1995). The migration of large numbers of people into the urban areas has been associated with high levels of urban poverty and deterioration of life style (Harpham & Stephens, 1991; Yach *et al.*, 1995). Frequently conditions in the urban centres are compared unfavourably to those in the rural areas with the theory that people leave an 'idyllic life' in the country side to live under socially, spatially and politically marginalised conditions in the cities (Hassan & Ahmad, 1991; Gelderblom & Kok, 1994). However, this stereotypic view ignores the fact that migration is usually necessitated by changing economic and social circumstances in the rural areas (Harpham & Stephens, 1991). In South Africa, increasing pressure from white farmers, the formation of the African reserves as well as the need to enter the cash economy contributed to the first mass migrations of people into the urban area (Lye, 1980b; Maylam, 1986; Gelderblom & Kok, 1994). Thus, urbanisation holds both positive and negative consequences.

2.2.2.2.1 *Consequences in rural areas*

The impact of migration out of rural areas on the health status of those people remaining in the rural areas has largely been ignored (Bryceson, 1989). Migration tends to be selective in that men between the ages of 15 and 30 years of age are the most likely to leave the rural areas. Also, it seems that the poorest people, probably with the least access to land, cannot afford the costs associated with migration, are least likely to migrate (Gelderblom & Kok, 1994). (In recent years in South Africa, the gender difference with regard to migration has disappeared to some extent (Gelderblom & Kok, 1994)). Traditionally, the women were responsible for working the land while the men were responsible for the cattle. The loss of young males from the rural areas has meant that the women have had to take over the men's responsibilities and that many of those remaining have little land or the resources with which to manage it. This has resulted in a reduction in rural household food production (Johnson & van der Westhuizen, 1989). At the same time the amount of land available for cultivation and for obtaining wood for fuel has been encroached on by large farms and industries, resulting in loss of both quantity and quality of available food (Brouwer *et al.*, 1989). The effects of these factors have generally been reflected in high incidences of protein-energy malnutrition in young children and folate and iron deficiencies in women (UNICEF, 1993). It is also generally accepted that past policies resulting in inequalities of access to land and resources have resulted in household food insecurity in the rural

and previous homeland areas of South Africa (Andersson & Marks, 1989; Vorster *et al.*, 1997a).

On the positive side, the money and gifts sent back to the rural areas by migrants make a substantial contribution to the rural family and are often the only source of livelihood for landless communities in the rural and closer settlements (Bryceson, 1989; Gelderblom & Kok, 1994). In addition, migration out of some rural areas may reduce the population pressure on the available land (Gelderblom & Kok, 1994). Also, with improved access to rural areas and contact between rural - urban dwellers, the reliance on home grown and gathered foods has been reduced, with increased availability of purchased food. This, together with other improvements such as the establishment of clinics and schools, improved water supplies and transport to towns, could have contributed to improved health status of the rural community (Walker, 1996).

2.2.2.2.2 *Consequences in urban areas*

In discussing the consequences of urbanisation of the health status of a population, differences within the urban setting must be distinguished. On the one hand, are the communities who have been living in urban areas for more than a generation, who have grown up in the urban setting, in established towns with formal infrastructures and facilities and whose life style is 'urban'. For these communities, urbanisation is accompanied by changes in lifestyle, including dietary and activity patterns from 'traditional' to those typical of urban societies. Improved socioeconomic conditions and the availability of a wide variety of foods results in the increase in the incidence of obesity related and noncommunicable diseases (Popkin *et al.*, 1992), including coronary heart disease (Steyn *et al.*, 1991), hypertension (Opie, 1995), stroke (Seedat *et al.*, 1992) and diabetes mellitus (Levitt & Mollentze, 1995). Greater access to health care results in beneficial effects such as a lowering of infant mortality rates, and improved quality of life (Kutty, 1989; Jiménez, 1993; Shi, 1993).

On the other hand, there are the recent arrivals and others who live in the overcrowded 'informal settlements' and towns (Solomons & Gross, 1995; Gelderblom & Kok, 1994). However, even with regard to these communities the following factors must be borne in mind:

- (a) Population growth in informal settlements is not only due to in migration, but also to

natural increase and that in some informal settlements many of the inhabitants are long term urban dwellers (Harpham & Stephens, 1991).

- (b) There is considerable heterogeneity within urban areas and thus there may be significant differences in both the health status and health needs of urban communities (Harpham, 1996). Informal settlements develop on the existing borders of the urban area and spread into the surrounding country side (urban sprawl), backyard squatting areas develop in established residential areas, the number of people per household increases and new suburbs develop on the periphery (Yach *et al.*, 1995).
- (c) In South Africa, urbanisation policies during the apartheid era caused many health problems in both urban and rural areas, for example, the maldistribution of health care workers, hospitals and clinics between the African and white areas and fragmented and unsystematic services in rural areas, the effects of which are still being felt (Bradshaw & Buthelezi, 1996; Doherty *et al.*, 1996b).

Thus, the effects of urbanisation on health status are complex and differ between areas and segments of the population. The most negative effects of urbanisation are seen in the informal settlement areas where shacks are constructed of corrugated iron or wood and daub and there is no or limited electricity, running water, sewage or refuse removal (von Schirnding & Yach, 1992). Overcrowding is common and associated with increased danger of infectious diseases such as gastroenteritis, respiratory tract infections and tuberculosis (Bradshaw & Buthelezi, 1996; Cooper *et al.*, 1991; Harpham & Stephens, 1991). In addition, community health care services are limited or not available (von Schirnding & Yach, 1992). Infants and young children are most at risk in these situations (Le Roux & Le Roux, 1991). Brockerhoff (1995), after a review of 15 demographic and health surveys from developing countries, concluded that children of migrants had up to double the risk of under five mortality than children of native urban dwellers. Coutsooudis *et al.* (1994) have reported multiple nutritional deficiencies in a sample of preschool children living in an informal settlement in Kwazulu/Natal. Infant mortality rates (IMRs) showed a marked decline during the 1970's and 1980's in the core areas of South African cities, but were considerable higher in the adjacent informal settlement areas (Yach, 1988). Also, of concern is the health of women (Pick *et al.*, 1990; Paolisso & Leslie, 1995) and the elderly (Gillis *et al.*,

1991) in informal settlement areas.

From the above discussion, it seems that the effects of urbanisation on health status may result in the contradictory situation of overnutrition and undernutrition existing simultaneously as has been reported from several countries (Pelto & Vargas, 1992; Popkin *et al.*, 1992; Romieu *et al.*, 1997). Also, it is difficult to draw clear-cut conclusions about differences in rural - urban nutrition. For example, in The Gambia, although the majority of urban dwellers have a better health status than their rural counterparts, there are urban communities where the health status is worse than that of rural communities (Harpham, 1996). The study of recent reviews on the nutrition and health status of the South African population confirms these observations (Fincham *et al.*, 1993; UNICEF, 1993; Hirschowitz *et al.*, 1995; Bradshaw & Buthelezi, 1996; Walker, 1996; Vorster *et al.*, 1997a).

2.2.3 Acculturation

Acculturation is a process which occurs concurrently to urbanisation, and yet may be distinct from urbanisation. To understand the concept of acculturation, the meaning of 'culture' must be clarified. Culture has been defined as the:

'total of the inherited ideas, beliefs, values and knowledge, which constitute the shared bases of social action' (McLeod & Hanks, 1985).

Members of a cultural group tend to display similar behaviours and beliefs, including food-related behaviours (De Garine, 1972; Pelto, 1981; Ritenbaugh, 1981). Acculturation occurs when two groups with different customs come into prolonged contact resulting in change, usually rapid, in the original behaviour and traits of either or both groups. Although both groups are usually affected, generally the culture of one group is changed more than that of the other (Dohrenwend & Smith, 1957; Schusky & Culbert, 1978; Palinkas & Pickwell, 1995). In general, acculturation is applied to the process whereby a traditional way of life is irrevocably altered to fit in with modern economic and social systems (Szathmary *et al.*, 1987).

The process of acculturation varies among different groups as well as among individuals within

a given population (Barnouw, 1950; Dubb, 1974). Thus, in terms of urbanisation, individuals who have lived for similar lengths of time in a town, may have undergone the process of acculturation to different extents. Dubb (1974) gives two case studies as examples of this. In the first case study, the individual had worked in an urban area (Johannesburg) for 20 years, lived in a council house and dressed in 'western clothes'. However, the interior of his home resembled that of a tribal hut, his wife dressed in traditional clothes and cooked and served meals in the traditional way. He thus only assumed those aspects of urban culture necessary for his survival in the city and maintained his traditional culture in all other areas. In contrast is the second case of a Tswana woman who maintains no 'traditional' practices, whose home resembles that of a home in a white urban area and who whose life style is typically urban.

Certain aspects of culture may be more or less sensitive to the influence of another culture than others. For example, traditional religious practices are often continued after other behaviours have changed. The resistance of an aspect of culture to acculturation has been linked to the importance and the time at which that practice was introduced to the child (Schusky & Culbert, 1978). As food behaviours are linked closely to the culture of a society, these behaviours, particularly those with symbolic or ritual associations are least likely to change (De Garine, 1972; Sekhukhune, 1993).

There is evidence that the degree of acculturation is influenced by certain characteristics of an individual. Studies on a range of population groups have shown that the older generation is less likely to change its practices, while the younger generations assume the practices of the new culture readily and may even look down on or reject the 'traditional' practices (Palinkas & Pickwell, 1995; Hodge *et al.*, 1996; Lee, 1996; Ritenbaugh *et al.*, 1996; Wolever *et al.*, 1997).

Socio-economic factors may also affect the extent of acculturation of food habits (Bryceson, 1989; Monteiro *et al.*, 1995). People with higher socio-economic status appear more likely to change the eating habits than those with a lower socio-economic status. In African populations, this phenomenon may possibly be linked to the symbolic meanings of food that designate social status within the society (Sekhukhune, 1993). In contrast, more recent data regarding changes in food behaviours suggest that urbanisation has a greater effect on dietary behaviours than economic changes (Drewnowski & Popkin, 1997).

Migration, urbanisation and acculturation are complex and interwoven processes which affect and are affected by a multitude of factors. For the remainder of this thesis, these aspects will be discussed only in terms of how they relate to the health status and specifically the dietary intakes of a population.

2.3 THE NUTRITION TRANSITION

2.3.1 The global perspective

Dietary behaviours are an integral part of the way of life of individuals, communities and populations and are determined by, among others, social, economic, cultural and environmental factors (Omolulu, 1971; De Garine, 1972; Peltó, 1981). Changes in any or all of these factors will both directly, through for example changed availability of foods and indirectly, such as through contact with other cultures, affect food behaviours (Kuhnlein, 1989). Thus, urbanisation and its accompanying social, cultural and economic changes have had profound effects on the diets, nutrition and health of populations (Drewnowski & Popkin, 1997).

2.3.1.1 Definition

The term 'transition' implies a change from one state to another (McLeod & Hanks, 1985). 'Health transition' has generally been applied to a process which has occurred or is occurring in developing countries and which is associated with urbanisation. Health policies and programmes, increased access to health services, education and immunisation have brought about decreases in fertility, birth, neonatal, infant and maternal mortality rates and improvements in life expectancy (Escovitz, 1992; Muñoz & Scrimshaw, 1995).

The health transition encompasses:

- (a) a demographic shift from a pattern of high fertility and mortality to one of low fertility and low mortality
- (b) an epidemiologic shift from a high prevalence of infectious diseases and malnutrition to an increasing prevalence of chronic and non communicable diseases (NCD) (Popkin,

1994).

Specifically, the term ‘nutrition transition’ refers to changes in the structure and composition of the diet reflected in both nutritional outcomes such as changes in average stature and body composition as well as in the epidemiologic profile of a population (Popkin, 1994). As nutrition changes are paralleled by major changes in the health status, demography and socioeconomic conditions of a population, it is difficult to explain the complex interrelationship (Popkin, 1994). Specifically, the nutrition transition refers to the change from traditional diets to diets high in saturated fat and refined carbohydrates and low in fibre (Popkin, 1994). It seems that both diets that are traditionally high carbohydrate, low fat (for example, traditional African and Asian diets (Walker, 1995; Popkin *et al.*, 1992) and animal-protein based diets (for example, Australian Aboriginal (Lee, 1996) and native Canadian (Szathmary *et al.*, 1987; Ritenbaugh *et al.*, 1996; Wolever *et al.*, 1997)), converge towards the so called ‘western’ diet and a globalisation of dietary behaviours whereby differences in dietary patterns of populations diminish (Drewnowski & Popkin, 1997).

The nutrition transition can be seen in both a positive and negative light. On the positive side, in countries such as China, where the traditional diet was limited to a few high carbohydrate staples, urbanisation has resulted in a wider availability of a variety of foods. Although this has led to higher fat consumption, the greater diversity of foods has improved the nutritional adequacy of the diet (Drewnowski & Popkin, 1997). On the negative side, the indigenous diets of many hunter-gatherer populations such as the Pedi and Tswana in South Africa (Quin, 1964; Franz, 1971), the Maori in New Zealand (Cannan & Walker 1996b) and the peoples of Papua New Guinea (Kuhnlein & Receveur, 1996) provided a wide diversity of foods ensuring nutritional adequacy. With the loss of their natural environments the indigenous sources of foods have disappeared and in most instances has been replaced by refined carbohydrate, increased fat and reduced fruit and vegetable intakes (Kuhnlein & Receveur, 1996).

2.3.1.2 The nutrition transition in other countries

The study of the dietary changes of immigrants from other cultures into a western culture such as Vietnamese, Cambodian and Asian immigrants in the USA (Crane & Green, 1980; Palinkas

Authors	Population / Province	Method of data collection	Staple foods	Other foods	Meal pattern	Signs of European contact
Walker <i>et al.</i> (1992) Studies: 1969 and 1989	Elderly Tswana NW	1969: 24-h recall foods depicting portion sizes 1989: 24-hour diet -frequency recall with food models	Maize	Bread, legumes vegetables, fruit, sugar, meat, milk	N/a	Change between 1969 and 1989 measure Maize meal and legume intake decreased, Brown bread, sugar, fruit and vegetable intake increased

*Adapted from Vorster *et al.*, 1997a; 1997b; Provinces: EC=Eastern Cape; NP=Northern Province; KZN=Kwazulu/Natal; NW=North West Province; ¶N/a=no information available

Table 2.2: Dietary patterns of urban African Southern African populations*

Authors	Population / area	Method of data collection	Staple foods	Other foods	Meal pattern	Signs of European contact
Manning (1974) Study: 1971	Xhosa Cape Town	Modified diet history	Maize meal Samp Samp and beans	Meat and vegetables consumed seldom - mainly on Sundays	Two - three meals per day; large special meal on Sundays	Use of bread, tea, instant cereals, rice potatoes. Frying popular as cooking method
Lubbe (1971a)	Venda	Modified diet history	Maize meal	Meat, bread, tomato and onion relish	Two to three meals per day between meal snacks	Increased use of bread, rice, meat and tea Low intakes of fruit and vegetables
Crous and Borchardt (1982) Study: 1979-1980	Pedi Gauteng (Atteridgeville)	Qualitative interviews	Maize meal	Bread, meat, vegetables	Three meals per day	Increased use of bread, meat, canned meat and fish and powdered milk. Decrease in maize products, sorghum, legumes, insects, wild fruit and vegetables
Crous and Borchardt (1984) Study: 1981	Venda Gauteng (Atteridgeville)	Qualitative interviews	Maize meal	Meat in small amounts, bread Green leafy and other vegetables Mopani worms	Three meals per day	Greater variety than rural; bread used 1-2x per day, legumes used seldom Low milk intakes Some traditional foods used
Benhura & Chitsiku, (1991) Study: 1989	Zimbabwe	Multiple 24-hour recalls	Maize (sadza)	Meat, mainly cultivated vegetables	Two to three	Diet similar to rural population. Lower consumption of wild vegetables and insects.
Bourne <i>et al.</i> (1994) Study: 1991	WC Xhosa	24-hour recall Habitual food intake questionnaire	Maize	Bread, rice; meat	Three meals per day	Adequate cereal, fat and meat intakes. Low intakes of milk, fruit and vegetables. Narrow range of foods
van Eeden and Gericke (1996)	Comparison of urban and rural	24-hour recall Food frequency of traditional foods	Maize meal	Meat and meat substitutes, milk; low intakes of fruit and vegetables in both groups	Three meals per day	Less use of traditional foods and preparation methods in urban group.
MacIntyre <i>et al.</i> (1998) Study: 1989-1993	African medical students	Estimated three day diet records	No predominant staple	High intakes of red meat, fried foods, refined carbohydrates and soft drinks	Three meals per day with between meal snacks	Diet typical of high fat, low fibre atherogenic diets

Adapted from Vorster *et al.*, 1997a; Provinces: EC=Eastern Cape; NP=Northern Province; KZN=Kwazulu/Natal; NW=North West Province; WC=Western Cape

From the above tables and the cited reviews, a trend in diet intakes can be proposed. The early studies generally report the use of a wide variety of foods and procurement methods thus ensuring adequate intakes. As pointed out by Franz (1971) and Grivetti (1979), this diversity may have been protective against the effects of food shortages brought on by drought or other natural disasters. The report by Waldman (1975) highlights the effects of drought, soil erosion, overgrazing and loss of land on the diet. From the varied and nutritionally adequate diet described by Quin (1964), soil erosion, overgrazing, drought and loss of land resulted in a monotonous diet and a scarcity of meat, milk, fruit and vegetables. Comparison of the reports from the Eastern Cape show a similar effect, with a marked reduction in the use of wild foods and an increase in the use of 'western' foods between the study of Hunter (1979) in the 1930's and that of Bembridge (1987) 50 years later. This contrast encapsulates the changes in the traditional diet of the African population. The extreme contrast to the traditional or rural diet has been seen in the diets of third year African medical students (MacIntyre *et al.*, 1998). The energy distribution of the students' diet (34%, 17% and 49% energy from fat, protein and carbohydrate respectively) was almost the same as that reported from second year medical students in USA (36%, 17% and 49% energy from fat, protein and carbohydrate respectively) (Troyer, 1990) and that reported from white boys in the Western Cape (35% energy from fat, 15% from protein and 49% from carbohydrate) (Steyn *et al.*, 1990). It is also noticeable from Tables 2.1 and Tables 2.2 that prior to 1980 dietary studies concentrated on rural populations so that little is known about the dietary patterns of urban Africans in this time.

The adoption of 'western' types of foods appears to have been gradual. The earlier studies on urban groups report use of a limited number of foods, mainly items such as tea, sugar and bread. Increased urbanization has resulted in the increased use of processed foods such as refined cereal products, canned meat and vegetables as well as new varieties of fruit and vegetables (Walker, 1996). Nevertheless, maize has remained the staple food even in urban areas.

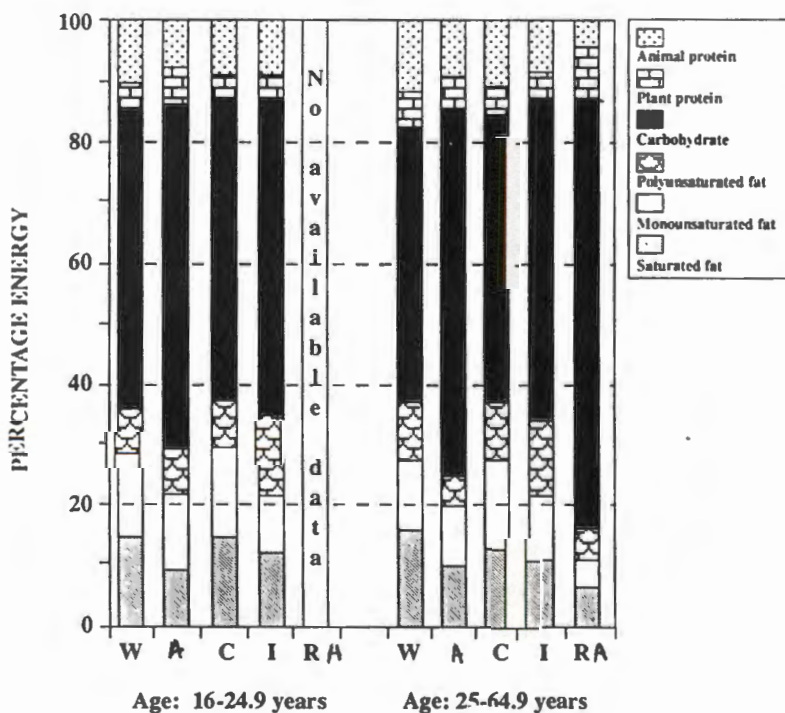
2.2.2.3

Nutrient intakes

Nutrient intake data obtained from studies carried out on South African populations have been reviewed by Labadarios *et al.* (1996), Walker (1996) and extensively by Vorster *et al.* (1997a; 1997b). Much of the data published between 1979 and 1994 has been combined in a meta-analysis by the South African Nutrition Survey Study Group (SANSS) (SANSS, 1995; Vorster *et al.*, 1997a; 1997b). Although several studies have been conducted on rural populations (Table 2.1) most of these reported only food intakes without nutrient analyses. Thus there is a lack of data on the nutrient intakes of rural populations.

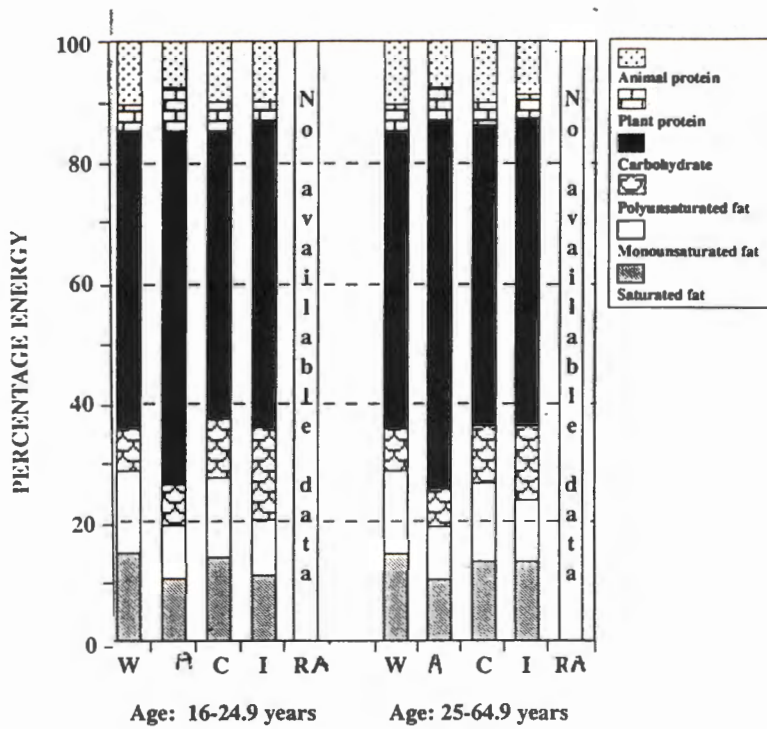
(a) *Macromutrients*

Figures 2.1 and 2.2 show the percentage of total energy supplied by carbohydrate, animal and plant protein, saturated, monounsaturated and polyunsaturated fat for females and males respectively for the various South African population groups.



W=whites; A=African; C=coloureds; I=Indians (Asians); RA=Rural African

Figure 2.1 Energy distribution of the diet of South African females (Vorster *et al.*, 1997a)



W=whites; A=African; C=coloureds; I=Indians (Asians); RA=Rural African

Figure 2.2: Energy distribution of the diet of South African males (Vorster *et al.*, 1997a)

The energy distributions of the white, Indian and coloured populations of both males and females were similar with fat providing between 34% and 39%, carbohydrate between 47% and 50% and protein between 15% and 20% of the total energy (Vorster *et al.*, 1997a). In contrast, the proportion of fat in the diet of urban Africans provides less than 30% and carbohydrate more than 57% percent of the total energy. The most marked differences are seen in the rural African population where fat contributes less than 20% and carbohydrate more than 60% of the total dietary energy. Of note is that the protein content is similar for all groups (Vorster *et al.*, 1997a). However, the proportion of plant protein exceeds that of animal protein in the African groups, while the opposite applies to the other groups (Vorster *et al.*, 1997a). Thus, in terms of urbanisation, the urban African diet appears to be transitional between that of the rural African and the white, coloured and Indian populations.

Table 2.3: Energy and nutrient intakes of African populations

Nutrient	Urban 15 - 24,9 years				Urban 25-64,9 years						¶ Rural (<20 - >50 years)		Rural 25-64,9 years	
	Males (N=58)		Females (N=61)		Males			Females			Males (N=266)		Females (N=95)	
	Mean	*SD	Mean	*SD	N	Mean	*SD	N	Mean	*SD	Mean	*SD	Mean	*SD
Energy (kJ)	8500	3500	6400	2900	383	8500	3726	481	6400	2629	15388	5977	10148	3325
Protein (g)	70	38	49	36	459	78,1	43,5	684	56,5	28,2	117,7	61,1	83	60
Total fat (g)	65	41	51	39	459	58,2	39,9	684	46,3	28,9	55,0	62,3	46	28
P/S ratio	0,72	0,5	0,92	0,56	383	0,8	0,7	481	0,9	0,7	-	-	-	-
Cholesterol (mg)	262	312	245	268	383	264	284	481	204	208	-	-	115	176
Carbohydrate (g)	298	129	219	91	459	282	112	684	222	88,9	583	193	409	122
Fibre (g)	21	12	17	11	459	19,5	13,5	684	14,6	8,8	25	15	37	16
Calcium (mg)	570	457	335	223	459	515	450	594	369	253	1614	191	343	274
Iron (mg)	9	4	7	4	459	10,5	5,8	594	7,5	3,7	446§	317	20	9
Magnesium (mg)	287	145	199	94	383	326	729	481	206	481	-	-	434	152
Sodium (mg)	2025	1431	1286	940	383	1517	1111	481	793	1072	3539	2285	835	843
Potassium (mg)	2044	976	1682	766	383	2212	1072	481	1730	781	5331	2975	2869	1154
Zinc (mg)	9,9	6,9	6,8	5,1	383	10,9	9,9	481	7,5	5,8	-	-	-	-
Vitamin A (RE)	373	399	452	848	383	640	2467	481	563	1125	662	633	-	-
Thiamin (mg)	1,1	0,6	0,8	0,5	459	1,2	0,8	594	0,9	0,6	3,4	1,7	2,1	0,7
Riboflavin (mg)	1,1	0,8	0,9	0,7	459	1,2	1,1	594	0,9	0,6	2,5	1,9	1,9	0,9
Niacin (mg)	13	8,1	9,4	5,6	459	15,8	10,2	594	12	7,1	31,1	20,6	22	10
Vitamin B6 (mg)	1	0,6	0,9	0,7	459	1,1	0,8	594	0,9	0,5	-	-	0,6	0,6
Vitamin B12 (µg)	3,4	4,7	3,2	9,5	459	23,9	6,1	594	3,9	9,9	-	-	2,2	4,9
Folic Acid (µg)	193	163	150	106	459	195	156	594	149	112	-	-	93	70
Vitamin C (mg)	61	150	53	108	459	46,3	123,8	594	43,5	72,8	57,7	90,5	33	39

Adapted from Vorster *et al.* (1997b), ¶Lubbe (1971), using modified diet history and weighed samples for 24-hours §Reported iron intake unrealistically high
 *SD: Standard deviation

(b) Micronutrients

Table 2.3 shows the means and standard deviations of selected minerals and vitamins of African populations derived from the meta-analysis of South African studies (Vorster *et al.*, 1997b). Only one study of rural subjects met the criteria for inclusion in the meta-analysis with the result that data is available only for rural females. The data of Lubbe (1971) is included in the above Table to give some indication of the dietary intakes of rural males. With the exception of calcium, mineral intakes appear adequate. Vitamin intakes are generally low, indicative of low fruit and vegetable intakes.

2.4 DIETARY ASSESSMENT

2.4.1 Dietary intake measurement methodologies

The measurement of dietary intakes of individuals and groups has been central to nutrition research since the 1930's (Nesheim, 1982; Medlin & Skinner, 1988). In 1947 Burke published what has become one of the basic models for dietary assessment when she described the dietary history as a 'tool for research' (Burke, 1947). Over the subsequent years, dietary assessment methodologies have been expanded, modified and refined as technology has advanced, statistical methods become more sophisticated and as the needs of dietary research have changed (Medlin & Skinner, 1988). In the past two to three decades, dietary intake measurement methodologies have developed into two broad categories: those for the measurement of the intakes of groups or households and those for the assessment of individual intakes. Under the former, are techniques such as the food account, food inventory, household record and list-recall methods (Nelson, 1991). Individual dietary assessment methodologies include diet history, 24-hour recall, weighed and estimated food records or diaries and food frequency questionnaires. Each method has specific uses, advantages and limitations. These methods have been recently and extensively described and reviewed by a number of authors, including Bingham (1987), Gibson (1990), Willett (1990), Bingham and Nelson (1991), Nelson (1991) and Thompson and Byers (1994).

Therefore, the basic characteristics, uses and limitations of the most commonly used methodologies are summarised in Table 2.4. The remainder of the review will concentrate on the methodologies used in South African dietary assessment studies and the food frequency questionnaire (FFQ) technique specifically with regard to the development of culture-sensitive instruments, sources of measurement errors, portion size estimation, reproducibility and validity, including the use of biomarkers.

Table 2.4: Summary of dietary assessment methodologies*

Instrument	Characteristics	Uses	Limitations
A. Household-based methodologies			
Food account	Record of quantities and types of food entering the household over a given period. Food consumption outside home estimated. Nutrient composition estimated.	National food consumption surveys Estimating food consumption trends for epidemiologic studies Populations in which most food is purchased Literate populations (respondents keep records themselves)	Possibly stimulates over purchasing during study period Data is only collected on foods brought into the home Large samples (>20 households) required Cannot estimate individual consumption
Food inventory	Record of quantities and types of foods entering the household over a given period plus an inventory of all foods in the household at the start and end of the study period.	As above Direct measurement of food available in a single household May be used to correlate food and nutrient availability with disease occurrence	May cause false purchasing and consumption patterns in household Cannot estimate individual consumption
Household record	Available foods weighed or estimated in household measures. Waste measured. Combination of recall and record may be used. Data collected by trained interviewers	Populations where large proportion of diet is home produced Populations with low or varied literacy. Identify households with specific consumption characteristics	Cannot estimate individual consumption Does not consider seasonal variations
List-recall	Structured interview in which respondent recalls amounts, costs and uses of food obtained over a given period	Estimates of food costs and household consumption of food and nutrients Populations where most food is purchased Quick and inexpensive	Rely on memory Amounts may be over or under estimated Cannot estimate individual consumption
B. Individual-based methods			
Diet records	Respondent weighs, measures or estimates all foods and beverages consumed over a given period. Foods and amounts recorded at time of consumption. Respondents supply recipes of composite dishes Records reviewed by a trained interviewer during and at the end of the recording period	Collection of quantitative data in literate populations	Requires literate and motivated respondents, thus may have sampling bias High respondent burden May induce changes to normal diet Underreporting common Coding and analysis time consuming

24-Hour recall	Respondent reports all food and beverages consumed over the preceding 24-hour period. Aids for portion size estimation may be used. More or less detailed information may be obtained, depending on the purpose of the study. Interviews conducted by trained interviewers with knowledge of local food availability and terminology	Measurement of current diet in groups of subjects Describes average intake of a group Suitable for use in populations with low literacy levels. Relatively quick, large samples can be assessed	All foods may not be reported Amounts may not be accurately reported Cannot characterise an individual's usual diet. Estimates tend to be lower than other methods
Multiple 24-hour recalls	As above, but repeated at different times. Number of repeats depends on the required level of precision, the population and the nutrients being studied.	Measurement of usual intake in a group	High cost and inconvenience of performing repeat interviews
Food frequency (FF)	Respondents report usual frequency of consumption of foods from a list for a specific period.	Estimates a usual intake Ranks individuals according to usual intakes within the population	Does not collect detailed data Estimation of quantities not as accurate as recalls or records Results may be influenced by foods included in the list
Semi-quantitative FF	Includes estimates of portion sizes such as small, medium and large or in comparison to a 'standard' serving	Suitable for measurement of dietary intake in epidemiologic studies Suitable for use in populations with low literacy levels	May produce either over- or underestimated amounts FF developed for one group may not be suitable for use with another
Quantitative FF	Includes more precise food portion size estimations such as weight or household measures Nutrient intakes obtained by summing over all foods the reported frequency x amount	Self-administered FF may be used in literate populations May be used to compare nutrient intakes of two or more groups	Does not provide information on day to day variations in diet Subject to interviewer bias
¶Diet history	Comprises three components: a. Detailed interview to determine usual pattern of eating b. Food frequency questionnaire c. Three-day diet record	Determines usual eating patterns over a relatively long period of time including type, preparation, frequency and amounts of foods consumed Does not depend on short term memory	Requires trained interviewers Interviews very time consuming Complexity of interview makes it more subject to interviewer bias than other methods May exaggerate regularity of diet habits As for FF
Direct observation	Researcher observes estimates or weighs food intake	Suitable for illiterate, child or elderly, institutionalised populations	Requires trained observers Presence of observer may affect food intake

¶Numerous modifications, including computerised versions (Slattery *et al.*, 1994), of the diet history exist. The term diet history is generally applied to methods which collect information on the characteristics, preparation methods, frequency and amounts of food consumed.

*Compiled from Beaton, 1979, Bazzarre and Yuhas, 1983, Stuff *et al.* (1983). Gibson (1990), Willett (1990), Bingham and Nelson (1991), Nelson (1991), Munger *et al.* (1992), Kushi (1994), Liu (1994), Thompson and Byers (1994) and Visser *et al.* (1995).

2.4.2 Culture-sensitive dietary assessment

From the preceding discussions on urbanisation, acculturation and the nutrition transition (Sections 2.2 and 2.3), it is clear that food intake is an integral part of the cultural setting of an individual or population. It therefore follows that the development of a dietary assessment method for a specific population takes the culture of that population into account (Kuhnlein, 1989; Cassidy, 1994; Hernandez, 1997; Jerome, 1997; Prewitt *et al.*, 1997; Teufel, 1997). Especially in the case of cross-cultural research (the researchers are not members of the study culture) this implies that the researchers first become familiar with the culture of the study population (Cassidy, 1994). This includes both the meanings a group attaches to food and its preparation, service and consumption, the language and the understanding of words used to name, describe and classify foods and the ways in which a group will react to the presence of an observer or interviewer (Cassidy, 1994) as well as information on the environment, food availability, food preparation and serving methods and local utensils (Jerome, 1997).

The most successful methods for the collection of this information are qualitative as these methods allow the respondents to express themselves in their own words and prevent researchers from imposing their own values and meanings on others (Cassidy, 1994). Several examples of the development of dietary assessment instruments for specific cultural groups exist in the literature. A common feature of most of these studies is the undertaking of a preliminary study to gather the information necessary for the development of the assessment tool. Methods used include direct observation (Zeitlin *et al.*, 1984; Jerome, 1997; Kigutha, 1997), 24-hour recalls (Adams-Campbell *et al.*, 1993; Wang & Block, 1997) and focus group techniques (Forsythe & Gage, 1994; Benavente & Pobocik, 1997;) or a combination of qualitative and quantitative methods (Cassidy, 1994; Campbell *et al.*, 1997). These techniques will be discussed in more detail with regard to the present study in Chapter 3.

2.4.3 Portion size estimation

One of the most difficult aspects of the collection of dietary data, irrespective of the method used, is obtaining accurate information on the amounts of foods consumed. The most accurate way is to weigh food before consumption and the plate waste remaining as is done in keeping

weighed records (Conn *et al.*, 1994). However, this requires that respondents are not only literate and numerate but also highly motivated. In order to simplify data collection specialised digital scales with voice recorders (Portable Electronic Tape Recorded Automatic or PETRA scales) have been developed and used in several British and European studies (Bingham, 1987). Unfortunately, this type of equipment is costly and also requires literate, accurate and motivated respondents. An alternative approach used in illiterate populations is that of trained observers weighing and measuring food in the households. The disadvantages of this method are that it is time consuming and expensive and intrudes into the respondents' life and normal behaviour patterns.

2.4.3.1 The need for portion size estimation

There is some argument as to whether the estimation of portion sizes is necessary for the collection of dietary data using FFQ. In some instances, the same average portion sizes are used for all respondents (Willett *et al.*, 1985; Block *et al.*, 1986). Some studies have shown only slight improvement in correlations in nutrient intakes when food frequency questionnaires with and without portion size estimation were compared with diet records (Cummings *et al.*, 1987; Hernandez-Avila *et al.*, 1988). As portion sizes vary less among individuals than do frequencies of intake, some researchers believe that the frequency of intake is sufficient to give information on dietary intakes of a population (Willett, 1990). In contrast, Chu and co-workers (1984) compared food and nutrient intake data of 342 males derived from frequencies only with intakes using portion size estimation. These researchers concluded that, although methods based only on frequencies of consumption gave comparative results to quantitative methods for aggregate food data, frequency data alone does not produce comparable results to quantitative methods for individual, food group or nutrient data. Thus, frequency dietary methods cannot be used to measure diet-disease relationships.

One of the most frequently used methods for estimating portion sizes is for the respondent to state his intake in terms of a 'standard' portion size, either given as a single size (Willett *et al.*, 1985) or as small, medium or large (Block *et al.*, 1986). However, a portion described as medium by one person may be described by another as large and by a third as small. Foods that

are naturally in a portion size, for example, an apple, slice of bread or an egg are thought to be simple to describe (Romieu *et al.*, 1997). The sizes of these foods, however, may also vary considerably. When students were asked to bring what they considered 'medium' sizes of commonly eaten foods to the researchers, Young and Nestle (1998) found wide variations in the perceptions of 'medium' with the range of size for all food items tested being at least twofold. Conn and co-workers (1994), after studying weighed records of portion sizes of a 126 foods, found that the 'typical' serving size of males was two to three times the standard portion. In addition, portion sizes were influenced by gender, age, socio-economic status and area. A way of overcoming this problem is to provide the respondents with a range of portion sizes for each food from which to estimate portion sizes. Another problem with the use of standard portion sizes is that respondents may interpret 'standard' as the 'average' or 'correct' portion size and thus give this size rather than using it to help to estimate their own portion sizes. Wheeler and co-workers (1994) overcame this problem by using the term 'reference serve' rather than 'standard serve' in their meal-based semiquantitative food frequency questionnaire.

2.4.3.2 Portion size measurement aids

The use of portion size measurement aids (PSMAs) may enhance portion size estimation (Guthrie, 1984). Little information is available in the literature regarding portion size estimation and the use of PSMAs in dietary intake studies. Most of the reviewed reports using semiquantitative food frequency questionnaires mention that quantities were given in one (Caan *et al.*, 1995) or three standard portion sizes and natural units (Willett *et al.*, 1985; Wheeler *et al.*, 1994; Goldbohm *et al.*, 1995; Bellú *et al.*, 1996a, 1996b; Kant and Thompson, 1997). Block and co-workers (1990) asked respondents to describe portions as small, medium or large in relation to a standard medium size and then adjusted portion sizes for age and gender. McNicol and Kaplan (1991) estimated portion sizes in household measures or natural sizes. It is also difficult to assess whether the standard portion sizes used were valid for the study population as few reports describe how these portion sizes were derived. Few are based on preliminary or other studies (Willett *et al.*, 1985; Block *et al.*, 1990; Hankin *et al.*, 1991; Bingham 1997; Lyu, 1998). Several studies mention portion sizes or refer to the food frequency questionnaire as 'semiquantitative' without specifying how portion sizes were determined (Salvini *et al.*, 1989; Bolton-Smith *et al.*, 1995; Feunekes *et al.*, 1995; Stevens *et al.*, 1996).

PSMAs mentioned include portion size photographs, usually in three sizes (Chu *et al.*, 1984; Hankin *et al.*, 1991; Petersen *et al.*, 1992; Elmståhl *et al.*, 1996a; Woo *et al.*, 1997; Lyu, 1998), portion sizes pictures or drawings (Kemppainen *et al.*, 1993), three-dimensional food models (Balogh *et al.*, 1968; Stein *et al.*, 1992) or combinations of pictures, utensils, models and containers (Samet *et al.*, 1984; Forsythe & Gage, 1994; van der Ster Wallin *et al.*, 1995; Klicka *et al.*, 1996). Ethangatta *et al.* (1996) adapted food models to be suitable for a dietary study in Kenya.

Some researchers have developed unique methods for the estimation of portion sizes. For example, Bird and Elwood (1983) have developed a method whereby respondents photograph their food portions. Other methods whereby the respondents estimate portion sizes by marking a tape have been used in developing countries (Zeitlin *et al.*, 1984). Ferguson and co-workers (1995) estimated portion sizes of their sample of Malawian women by asking the respondents to serve a portion of a salted sample of actual food using their own utensils and then weighing the portions.

A review of Southern African dietary surveys showed that the most commonly used PSMAs were household utensils and food models. In surveys conducted at the respondents' homes, respondents may be asked to demonstrate the utensils and portion sizes they usually serve (Langenhoven *et al.*, 1988; Huss-Ashmore & Curry, 1991). Some researchers have developed 'measuring kits' based on preliminary studies to assist field workers to estimate portion sizes from the respondents' responses (Bourne *et al.*, 1994). Food models have been used in combination with household measures (Wolmarans *et al.*, 1989; Walker *et al.*, 1992) and with actual foods (Steyn *et al.*, 1986; Walker *et al.*, 1992; Vorster *et al.*, 1994).

It is difficult to assess the use and effectiveness of PSMAs in dietary surveys as only a few reports give information regarding the development, use and characteristics of the PSMA. For example, of the studies mentioned above only Chu *et al.* (1984), Stein *et al.* (1992), Elmståhl *et al.* (1996a) and Cleveland *et al.* (1997) provide descriptions of the PSMA used.

There are also few studies on the testing and validation of PSMAs. In 1997, Cypel and co-workers published a review of PSMA validation studies which evaluated five studies. The use

of food photographs as PSMA's have been evaluated by Nelson *et al* (1994; 1996) and Robinson *et al.* (1997). The evaluation of PSMA's in the present study is discussed in detail in Chapter 4.

2.4.4 Sources of error in dietary assessment

The aim of dietary assessment is to measure the true intakes of the target population. The assessment of dietary intakes in free-living populations is, however, subject to a variety of errors, irrespective of the method used. Some sources of error are common to all methods, while others are method specific.

2.4.4.1 Natural variation of diets

According to Willett (1990), a central feature of the dietary intake of free-living individuals is day-to-day variation superimposed on an underlying consistent pattern. Factors including day-of-week or month, season, work and recreational patterns and state of health contribute to this variation (Willett, 1990). These daily variations contribute to the intra individual variability of the diet in contrast to the inter individual variations produced by differences between individuals such as gender, age, activity level and weight status (Krall *et al.*, 1988). The degree of variation differs according to nutrient (Willett, 1990). Variation is less for macronutrients than for micronutrients which tend to be concentrated in certain foods, so that daily intakes may be high or low, depending on the foods consumed on a given day (Willett, 1990). To overcome this problem requires that a large number of days be measured or that large sample sizes be used. The use of food frequency questionnaires which inquire about a period of time rather than a single day, may also help to reduce this type of error. (For a discussion on the number of days needed to estimate true dietary intakes, see Section 2.6.1.3).

2.4.4.2 Measurement error

Apart from intra-individual random variation, over which the researcher has little control, dietary assessment is subject to errors of measurement relating to the subjects, the measurement instrument itself, the mode of administration and the information of the nutrient content of foods. This review will focus on the errors introduced into dietary assessment by the subjects themselves

and by the format and administration of the measurement instrument. It is important to note, however, that all methods that use food composition tables for the analysis of the nutrient content of foods are subject to the same errors of variability, inaccuracy, missing values, preparation losses and differences in absorption and bioavailability (West & van Staveren, 1991; Bellù & Cucco, 1997). For in depth discussions of the use of food composition tables in dietary assessment, the reader is referred to Bingham (1987), Gibson (1990) and West and van Staveren (1991).

(a) *Respondent bias*

Since retrospective dietary assessment methods make use of recalled information, they rely on the subject's ability to retrieve the relevant information from memory, process it and provide reasonable answers, usually within a short period of time (Smith *et al.*, 1991; Smith, 1993). Asking a subject to recall frequencies, implies some form of calculation from a simple number to a rate (number of times per week or per month). Subjects may truly not remember their food consumption accurately, and thus omit foods consumed; they may make inferences using partial information from memory to provide answers or they may simply give an answer they think is appropriate, whether that food was consumed or not (Bradburn *et al.*, 1987; Dwyer *et al.*, 1987; Smith, 1993). Recall may be assisted by making use of memory aids such as food models, actual foods or pictures (see 2.4.3 and Chapter 4). Recently a number of papers have been published which look into the links between cognitive psychology and dietary recall and propose ways in which recall could be improved by applying cognitive principles to the formulation and administration of dietary questionnaires (Bradburn *et al.*, 1987; Smith *et al.*, 1991; Fisher & Quigley, 1992; Rappoport *et al.*, 1992; Smith, 1993; Baranowski & Domel, 1994; Baxter *et al.*, 1997a). Other sources of bias could be due to the respondent's desire to give socially acceptable responses (Hebert *et al.*, 1995) or failure to understand the question (Gibson, 1990).

Respondent biases may be random across days for an individual or may be systematic, with some individuals consistently over or underreporting (Beaton, 1991). This may be especially true for persons with certain characteristics such as overweight subjects who may underestimate intakes or responses on alcohol consumption (Gibson, 1990; Rehm & Spuhler, 1993).

(b) *Interviewer bias*

Interviewer biases include errors caused by incorrect questions, incorrect recording of responses, intentional or unintentional omissions (Gibson, 1990). Personal characteristics of the interviewer such as age, gender, social background, ethnic group or manner of speech may all affect the way the respondent answers questions (Frank *et al.*, 1984). Respondents may pick up intentional or unintentional cues in the interviewer's tone of voice, an expectant pause, or the interviewer agreeing in an effort to maintain rapport (Lydeard, 1991). Interviewer bias can be reduced by use of quality control methods such as careful planning, training interviewers and regular checks of interviewers during data collection (Haraldsdóttir, 1993).

(c) *Errors in food frequency questionnaires*

Apart from the above errors which are common to all retrospective questionnaires, food frequency questionnaires, as a result of their structure of a precoded list of foods and estimation of frequency of consumption, may give rise to other errors. Factors that may contribute to errors are the following:

- i. Since the food frequency questionnaire is based on a preset list of foods, omissions of foods from the food list may result in underestimation of intakes (Beaton, 1991; Sempos, 1992).
- ii. Grouping of foods together into groups may result in the loss of information concerning preparation methods and differences in the types of individual foods (Sempos, 1992).
- iii. No information is given about foods consumed together as meals or mixed dishes and the sizes of individual portions (Sempos, 1992).
- iv. Respondents have to remember all dishes which contain a given item, separate mixed dishes into their component foods, estimate the amount they usually consume, add it together with other sources of the food and then estimate the frequency of consumption (Bingham, 1987; Sempos, 1992). This may result in subjects making inferences from the foods most easily estimated or simply guessing amounts and frequencies (Bradburn *et al.*, 1987).
- v. Semiquantitative food frequency questionnaires which make use of average

portion sizes may result in over or underestimation depending on the difference between the average portion size and the actual amount of food consumed (Beaton, 1991).

- vi. Subjects may be unable to recall or aggregate past eating patterns of a month or a year accurately (Beaton, 1991).

(d) *Errors of diet records*

Diet records are discussed in more detail in Section 2.6. Thus the shortcomings of this method, in addition to those common to other assessment methods, are briefly mentioned here. Diet records are subject to measurement errors by subjects not using the scale correctly in weighed intakes or making inaccurate estimates using household measures (Bingham, 1987; Borrelli *et al.*, 1989). A serious drawback is that the act of keeping the record might cause respondents to consciously change their eating habits to simplify measurement or to impress the researcher (Sempos *et al.*, 1985; Bingham, 1987; Salvini *et al.*, 1989; Streit *et al.*, 1991; Thompson & Byers, 1994; Heitmann, 1996; Mela & Aaron, 1997). Unavoidable circumstances might interfere with the keeping of the record (Macdiarmid & Blundell, 1997). There is some evidence to suggest that underreporting may be subconscious as the degree of underreporting seems to increase with increased attention to food intake (Mertz, 1992).

2.5 REPRODUCIBILITY

Reproducibility (also referred to as reliability) is the degree of similarity of the information obtained when a measurement instrument, usually a food frequency questionnaire in dietary intake studies, is administered to the same individual or group on two or more occasions (Katzenellenbogen & Joubert, 1997). Reproducibility may be defined as the extent to which a measurement instrument is free from random errors, that is, non-systematic ever-changing influences on the information (Männistö *et al.*, 1996) and is measured by applying the same measurement instrument to the same subjects on two or more separate occasions and under similar conditions (Dunn, 1989; Judd *et al.*, 1991).

There are two underlying assumptions of reproducibility studies. First, is the assumption that the

variable of interest is stable over time (Dunn, 1989). In dietary intake studies, this implies that food intake and factors affecting food intake, such as seasonal variation, have not changed during the time between repeat administrations of the instrument (Schmidt *et al.*, 1994). This assumption may not always be true, however, it is likely to be approximated when long term intakes are measured (Hebert & Miller, 1991). The repeat administrations should be far enough apart so that the respondents cannot remember specific responses from the first to the second administration, but close enough together so that changes in usual dietary intakes, for example, due to seasonal variation, are minimal (Judd *et al.*, 1991). The second assumption is that measurement errors are uncorrelated, that is, errors occurring in the second administration are not related to those which occurred in the first administration (Dunn, 1989). Part of the measurement error, however, may be correlated between the two measurements with the same instrument, giving spuriously high correlation coefficients (Goldbohm *et al.*, 1995). This may occur, for example, when a subject interprets ambiguous wording of a question or misunderstands a portion size in the same way on both occasions.

The test-retest correlation is the most commonly used estimate of an instrument's reproducibility (Judd *et al.*, 1991). Several authors, however, have pointed out the limitations of the correlation coefficient in validation and reproducibility studies (Hebert & Miller, 1991; Bellach, 1993; Delcourt *et al.*, 1994). Correlation coefficients show the extent to which two variables are linearly related and thus do not give a measure of agreement (Hebert & Miller, 1991; Bellach, 1993). In order to adequately interpret the results of reproducibility studies more than one type of analysis is necessary (Hebert & Miller, 1991). In the light of the limitations of correlation coefficients, the results of reproducibility studies should be analysed in several ways (Bellach, 1993). Reproducibility may also be expressed as the difference or percentage difference between the means of the two measurements (Lindroos *et al.*, 1993; Schmidt *et al.*, 1994; Feunekes *et al.*, 1995; Stevens *et al.*, 1996), in terms of the ranking of subjects within the distribution on each of the measurements (Basch *et al.*, 1994; Wheeler *et al.*, 1994; Feunekes *et al.*, 1995) and by means of the Bland-Altman plots (Bland & Altman, 1986). Direct comparison of reproducibility results from different studies is, however, difficult. Apart from the usual differences in sample composition and size, there are a number of methodological differences.

- (a) Different measures of test-retest correlation are reported in the literature. Some authors report reproducibility as the Pearson correlation coefficient (Munger *et al.*, 1992; Lindroos *et al.*, 1993; Ajani *et al.*, 1994; Basch *et al.*, 1994; Forsythe & Gage, 1994; Wheeler *et al.*, 1994; Feunekes *et al.*, 1995; Rockett *et al.*, 1995), some as intraclass correlations (Smith *et al.*, 1996), some as both Pearson and intraclass correlations (Willett *et al.*, 1985; Rimm *et al.*, 1992; Schmidt *et al.*, 1994; Männistö *et al.*, 1996) while others report Spearman rank correlation coefficients (Wheeler *et al.*, 1994; Riboli *et al.*, 1997). The intraclass correlation assesses the within-subject variation (Schmidt *et al.*, 1994; Männistö *et al.*, 1996). Stevens and co-workers (1996) have expressed the correlation coefficients between repeat administrations as 'reliability coefficients' which are estimated by the ratio of the sample covariance to the mean of the intake variances of the first and second administrations.
- (b) Studies differ in the treatment of data before analysis. For example, in some studies the data was log transformed to improve normality (Munger *et al.*, 1992; Ajani *et al.*, 1994; Basch *et al.*, 1994; Wheeler *et al.*, 1994; Rockett *et al.*, 1996). Also, both crude and energy adjusted nutrient intake data is reported (Munger *et al.*, 1992; Ajani *et al.*, 1994; Wheeler *et al.*, 1994; Rockett *et al.*, 1996; Männistö *et al.*, 1996; Riboli *et al.*, 1997) while some authors do not specify how the data was treated (Forsythe & Gage, 1994; Schmidt *et al.*, 1994; Smith *et al.*, 1996).
- (c) The time interval between repeat assessments varies from one week (Forsythe & Gage, 1994) to five years (Goldbohm *et al.*, 1995).
- (d) Although most reproducibility studies are reported for semiquantitative food frequency questionnaires, the format and mode of administration vary among studies. While the majority of reports are from self administered, food-group-based questionnaires, some questionnaires were administered by interviewers (Smith *et al.*, 1996) and others were meal-based (Wheeler *et al.*, 1994; Schmidt *et al.*, 1994).
- (e) It is not always possible to identify whether poor reproducibility is caused by the

measurement error of the instrument, changes in dietary intake, or both, especially in studies which have only repeated the measurement once (Goldbohm *et al.*, 1995).

Despite the above differences, a review of the results of reproducibility studies gives an indication of the extent to which random error affects dietary intake results under different circumstances as well as the range of test-retest correlations and differences to be expected for different nutrients.

2.5.1 Measurement of reproducibility

2.5.1.1 Test-retest correlation

Table 2.5 summarises the test-retest correlation results for energy and selected nutrients of certain reproducibility studies conducted since 1990. The nutrients shown in the Table are those which are tested in the present study. Studies are classified according to the time interval between administrations and the number of administrations. For simplicity, unless otherwise stated, the Pearson correlation coefficient is given for crude data and values for vitamins and minerals do not include supplements. For a review of studies prior to 1990, the reader is referred to Willett (1990).

Table 2.5: Summary of correlation coefficient results of reproducibility studies since 1990.

Authors	Sample	Type of FFQ	Time interval	Test -Retest correlation										
				Energy	§Prot	CHO	Fat	Chol	Fibre	Ca	Fe	Vit A	Vit C	Alcohol
A. One repeat administration: interval between administrations less than 12 months														
Smith <i>et al.</i> , 1996	Pima Indian adults N=55	*QFFQ †IA Same * Different interviewer	-	0,72 0,76	0,65 0,68	0,63 0,76	0,75 0,69	-	-	-	-	-		
O'Donnel <i>et al.</i> , 1991	Adults age 18-65 years N=49	**SQFF ‡SA	4 months weighed record during interval	0,66	0,58	0,74	0,64	-	0,71	0,60	0,64	0,75	0,81	0,88
Lindroos <i>et al.</i> , 1993	Obese adults N=111	**SQFF ‡SA	3 months	0,73	0,72	0,72	0,72	0,61	0,61	-	-	-	-	0,89

Authors	Sample	Type of FFQ	Time interval	Test -Retest correlation										
				Energy	gProt	CHO	Fat	Chol	Fibre	Ca	Fe	Vit A	Vit C	Alcohol
Forsythe & Gage, 1994	Pregnant women Multicultural =30	**SQFF †IA	1 week	0.91	0.97	0.83	0.89	-	-	0.87	0.79	0.73	-	0.69
Feunekes <i>et al.</i> , 1995	Adult males and females N=93	**SQFF †IA Specific for fat intake Same interviewer	2 months	0.91	-	-	0.87	0.84	-	0.65 0.59	0.76 0.85	-	-	-
Männistö <i>et al.</i> , 1996	Adult females N=152	**SFFQ ‡SA	3 months	*0.66	0.66	0.69	0.62	0.71	0.69	0.71	0.68	0.66	0.7	0.64
B. One repeat administration: time interval between administrations 12 months or more														
Rimm <i>et al.</i> , 1992	Adult male health professionals N=127	**SQFF ‡SA ^a	12 months	0.65	0.64	0.63	0.66	0.67	-	-	0.54	0.63	0.69	-
Schmidt <i>et al.</i> , 1994	Adult IDDM Intensive treatment N=139 Conventional treatment N=128	***MDH	12 months	0.70	0.66	0.71	0.65	-	0.51	-	-	-	-	-
				0.76	0.72	0.69	0.72	-	0.51	-	-	-	-	-
Ajani <i>et al.</i> , 1994	Adult males & females in eye disease case-control study N=281	SQFF SA ^a	12 - 18 months	0.51	0.55	0.65	0.70	0.71	0.66	0.63	0.58	0.59	0.54	0.79
Rockett <i>et al.</i> , 1995	Multi ethnic youths 9 to 18 years N=179	SQFF SA ^a	12 months	0.49	0.26	0.34	0.41	-	0.51	0.58	0.26	-	-	-
Elmståhl <i>et al.</i> , 1996a	Adults 50-69 years N=64 N=57	QFFQ SA ^a Six 3-day w ^h during interval	12 months	0.71	0.57	0.77	0.63	0.49	0.65	0.76	-	0.42	0.66	0.88
				0.75	0.77	0.68	0.75	0.62	0.59	0.85		0.77	0.77	0.74
Stevens <i>et al.</i> , 1996	Adult white: males N=115 females N=164 black: males N=54 females N=86	SQFF IA	3 years	0.68	0.64	0.67	0.62	0.61	0.63	0.69	0.57	0.4	0.63	-
				0.50	0.45	0.52	0.48	0.41	0.56	0.52	0.42	0.46	0.55	
				0.48	0.50	0.33	0.60	0.55	0.58	0.45	0.54	0.49	0.33	
				0.41	0.49	0.34	0.52	0.52	0.41	0.26	0.38	0.31	0.30	
C. More than one repeat administration: time interval between administrations less than 12 months														
Wheeler <i>et al.</i> , 1994	Adults N=54; 48;42	3 formats of meal-based SQFF SA ^f	4 - 6 weeks	0.57-0.81	0.57-0.76	0.59-0.79	0.62-0.79	0.7-0.78	0.6-0.62	0.65-0.79	0.52-0.78	0.3-0.68	0.7-0.76	0.78-0.88
	N=98		3 months	0.78	0.78	0.75	0.77	0.80	0.73	0.67	0.76	0.62	0.76	0.69

Authors	Sample	Type of FFQ	Time interval	Test -Retest correlation										
				Energy	§Prot	CHO	Fat	Chol	Fibre	Ca	Fe	Vit A	Vit C	Alcohol
D. More than one repeat administration: time interval between administrations less than 12 months and 12 months or more														
Munger <i>et al.</i> , 1992	Adult females 55 - 69 years N=44	SQFF SA*	24 months 30 months 5 months	0.51	0.59	0.47	0.51	0.53	0.57	0.63	0.47	0.58	0.69	0.99
				0.61	0.70	0.54	0.60	0.59	0.60	0.66	0.58	0.63	0.57	0.98
				0.67	0.74	0.66	0.71	0.64	0.82	0.76	0.81	0.69	0.81	0.99
Basch <i>et al.</i> , 1994	Low income Latino mothers N=166	SQFF IA	3 months 12 months	0.59	0.49	0.59	0.60	0.51	-	-	-	0.58	0.53	-
				0.51	0.42	0.54	0.47	0.36				0.46	0.43	
Goldbohm <i>et al.</i> , 1995	Adult males N=703 females N=710	SQFF SA Repeated annually for 5 years	45 years M F	0.68	0.57	0.71	0.63	0.66	0.68	0.59	-	0.51	0.62	0.85
				0.64	0.61	0.67	0.56	0.65	0.66	0.63	-	0.52	0.64	0.84
Riboli <i>et al.</i> , 1997	Adult females *N=223	SQFF SA†	2 - 3 months 2 - 5 years	0.54	0.56	0.59	0.54	0.66	0.66	0.56	-	0.57	0.62	-
				0.45	0.45	0.49	0.41	0.47	0.53	0.49		0.36	0.52	

§ Abbreviations of nutrients: Prot:protein; CHO: carbohydrate; Chol: cholesterol; Ca: calcium; Fe: iron; Vit A: vitamin A; Vit C: vitamin C

*QFFQ: quantitative food frequency questionnaire; **SQFF: semiquantitative food frequency questionnaire; ***MDH: modified diet history

†IA: interviewer administered; ‡SA: self administered

- No values given

^a Intraclass correlation coefficient

^b Adjusted for energy intake

^c β-carotene only

^d Mean of 5 annual repeat administrations

^e Respondents to three FFQ. Long term reproducibility of 188 respondents who did not complete short term reproducibility study not shown.

^f Spearman rank correlation coefficient

^g weighed records

Table 2.5 shows the wide range of correlation coefficients for reproducibility studies reported in the literature. Correlations vary from weak as for energy and iron for multiethnic youths (Rockett *et al.*, 1995) to very strong almost perfect correlations for alcohol of elderly adult females (Munger *et al.*, 1992) and protein for pregnant women (Forsythe & Gage, 1994). Most correlations (approximately 50%) are strong (0,6 - 0,8) and approximately one third are moderate (0,4-0,59). The limitations of the use of the correlation coefficient must be kept in mind when interpreting the above results.

2.5.1.2 Differences between mean intakes of repeat measures

There is far less emphasis on the mean intakes and the differences between mean intakes of repeat measurements than there is on test-retest correlation in the literature. While some studies report the percentage difference between the means of the first and second measurements (usually as a percentage of the first measurement) (Schmidt *et al.*, 1994; Wheeler *et al.*, 1994; Feunekes *et*

al., 1995), others list the means (Willett *et al.*, 1985; Stevens *et al.*, 1996; Riboli *et al.*, 1997) or the medians (Nes *et al.*, 1992) of each measurement and others merely state that the means showed little difference or remained stable between measurements (Munger *et al.*, 1992; Forsythe & Gage, 1994). Mean intakes appear to differ very little between measurements irrespective of the number of repeats and the time interval between repeat measurements. For example, Riboli and co-workers (1997) found no meaningful changes in mean intakes of the long term reproducibility (two to four years) or the short term reproducibility (three weeks) studies. Wheeler *et al.* (1994) reported mean reductions of 12%, 10% and 13% on their three formats of questionnaires over four to six weeks but a mean difference of less than 4% over three months.

In general, the reported mean energy and macronutrient intakes are slightly lower on the second measurement than on the first and differences in micronutrients are variable (Willett *et al.*, 1985; Nes *et al.*, 1992; Lindroos *et al.*, 1993; Ajani *et al.*, 1994; Wheeler *et al.*, 1994; Feunekes *et al.*, 1995; Rockett *et al.*, 1995; Elmståhl *et al.*, 1996a; Stevens *et al.*, 1996). In contrast, Schmidt *et al.* (1994) and Männistö *et al.* (1996) found lower reported mean intakes on the first than on the second measurement. Apart from seasonal changes of food patterns (Wheeler *et al.*, 1994), no reasons for the differences in mean intake have been discussed in the cited references.

2.5.1.3 Classification of subjects within the distribution

As one of the main purposes of FFQs is to rank individuals within a population, it is important to know whether the classification of individuals into subgroups is the same on both administrations of the questionnaire (Kune *et al.*, 1987). Unfortunately, few reproducibility studies have compared distributions and those that have, have used different classifications of the distribution. Feunekes *et al.* (1995) and Wheeler *et al.* (1994) classified their distributions into tertiles and reported 61% to 74% and 50% to 76% subjects classified into the same tertile on both measurements. Basch *et al.* (1994) found that 50% of their subjects were classified into the same quartile on the first measurement and one year later on the second measurement. Kune and co-workers (1987) could classify 80% or more subjects into the same or adjacent quintiles on repeat measurements with an interval of four to eight weeks.

2.5.2 Reproducibility of food intake data

Several studies have tested the reproducibility of food intakes in addition to nutrient intakes. In general, reported correlations are higher for frequently consumed foods than for seldom used foods (Ajani *et al.*, 1994; Feunekes *et al.*, 1995). Beverages including liquor, tea, coffee, soft drinks, milk and fruit juices are among the highest correlations in most studies (Ajani *et al.*, 1994; Feunekes *et al.*, 1995; Rockett *et al.*, 1995; Männistö *et al.*, 1996). Reproducibility of meat and meat dishes was low in some studies (Ajani *et al.*, 1994; Männistö *et al.*, 1996; Rockett *et al.*, 1995) but relatively high in others (Kune *et al.*, 1987; Riboli *et al.*, 1997). Cereals, particular those consumed regularly showed good reproducibility (Kune *et al.*, 1987; Ajani *et al.*, 1994; Feunekes *et al.*, 1995). With regard to the interval between repeat measurements, the reproducibility of foods showed a similar trend to that of nutrients being higher in the short than in the long term (Riboli *et al.*, 1997). Differences between mean food intakes on repeat measurements were both positive and negative, but, as for nutrients, were small (Feunekes *et al.*, 1995).

2.5.3 Factors affecting reproducibility

2.5.3.1 Timing and number of repeat measurements

The highest correlation coefficients obtained in the reviewed studies (Table 2.5) were by Forsythe and Gage (1994) with an interval of one week between measurements. Dietary intakes are unlikely to change in such a short period, but subjects may have repeated their answers from the previous administration rather than assessing their dietary intakes afresh. It is generally accepted that such a short interval between repeat measures cannot give a meaningful measure of reproducibility (Judd *et al.*, 1991). Of the other studies with intervals of three or fewer months, the reproducibility of the FFQ of Feunekes *et al.* (1995) gave correlation coefficients of greater than 0.8. This may have been due to the fact that the FFQ was specifically directed at assessing energy and fat intakes and comprised a fairly limited number of foods. Comparison of reproducibility at four to six week and three months intervals yielded virtually the same results (Wheeler *et al.*, 1994). Most of the reproducibility coefficients obtained for the studies with

intervals of 12 months or longer are comparable to each other and to those with shorter intervals.

The studies which have compared reproducibility over short and long intervals, have recorded slightly higher levels of reproducibility of the short than the long term for most nutrients (Munger *et al.*, 1992; Basch *et al.*, 1994). The largest differences were shown by Riboli and colleagues (1997) between a three-month and a two to five-year interval. The study reported by Goldbohm and co-workers (1995) provides an additional insight into reproducibility in that these workers studied reproducibility over a five-year period and then removed the time effect from their data. They showed that the correlation coefficient decreased on average by 0,02 per year for energy adjusted nutrient intakes.

A factor which may affect reproducibility when more than one repeat measurement is given is the 'training effect', that is, as respondents become familiar with the questionnaire, the reproducibility improves (Munger *et al.*, 1992). A similar effect is likely to occur when respondents participated in other dietary assessment methods, such as weighed records, during the interval between FFQ measurements. This is shown by the higher Pearson correlation coefficients (except for alcohol and fibre) obtained by the group of subjects who completed six, three-day weighed records between the test and the retest compared to the group who completed only the test and retest questionnaires in the reproducibility study conducted by Elmståhl and co-workers (1996a).

Another methodological factor which might account for some of the differences in reproducibility of various studies is whether the questionnaire was self administered or whether it was administered by an interviewer. The reviewed studies show a similar range of correlations regardless of the manner of administration. However, as the studies differ in a considerable number of ways, no conclusion about reproducibility and mode of administration can be drawn.

2.5.3.2 Sample characteristics

Stevens and colleagues (1996) compared the reproducibility of a food frequency questionnaire according to ethnicity, gender, age and education and found that white race, male gender, having more than 12 years of education and being younger than 55 years of age were associated with higher levels of reproducibility. In other studies, the reproducibility of the female subjects was

better than that of the male subjects (Ajani *et al.*, 1994; Feunekes *et al.*, 1995; Goldbohm *et al.*, 1995). The weakest correlations were obtained in youths (Rockett *et al.*, 1995) while the correlation obtained for elderly women (Munger *et al.*, 1992) were within a similar range to the reports. With regard to education level, the only study which specifically mentioned that the subjects were non-English speakers with low education levels was that of Basch *et al.* (1994) on low income Latino mothers. The range of correlations (0,36 to 0,51) after a 12-month interval, appears to be similar to that of black males and females (0,3 to 0,6) (Stevens *et al.*, 1996) and of multi ethnic youths (Rockett *et al.*, 1996) and lower than that of other studies of a one year interval (Rimm *et al.*, 1992; Schmidt *et al.*, 1994; Ajani *et al.*, 1994; Stevens *et al.*, 1996).

Where reproducibility has been tested in case-control studies (Ajani *et al.*, 1994; Schmidt *et al.*, 1994) only slight differences have been found between the results of the cases and the controls. Ajani *et al.* (1994) found that, although there were differences in the reproducibility of some nutrients, overall reproducibility for control subjects was slightly higher than for case subjects.

In the study of Schmidt and co-workers (1994) on dietary intakes of diabetic patients receiving conventional treatment compared to intensive treatment, the Pearson correlation coefficients were slightly higher in the conventional treatment than in the intensive treatment group.

2.6 RELATIVE VALIDITY

Validity has been defined as the degree to which a measuring instrument reflects only the true value of the desired characteristic without contamination by random or systematic errors (Bailey, 1987; Judd *et al.*, 1991). Put another way, validity is the absence of bias (Abdool Karim, 1997), where bias refers to any systematic error in the way a study is conducted, analysed or reported (Beaton, 1994; Margetts & Nelson, 1995). Thus, in relation to dietary assessment, to be valid, a dietary intake measurement instrument must measure the aspects of diet it was intended to measure (Willett, 1989; Gibson, 1990; Margetts & Nelson, 1995). Validity has two implicit components: the first is that the instrument actually measures what it is meant to and the second is that the measurements are accurate, that is, reproducible (Bailey, 1987). Clearly, to be valid, the instrument must have a satisfactory level of reproducibility. On the other hand, the instrument may be highly reproducible but not valid (Bailey, 1987; Willett, 1990). For example, if a food

frequency questionnaire omits oranges, it may give similar vitamin C intakes on each repeat measurement, but it fails to give the true intake of vitamin C and therefore is not valid.

Validation of a dietary assessment instrument implies that the true intakes of the factors under consideration are known (Block, 1982). True dietary intakes of individuals, however, can never be known with absolute certainty. For example, even if the results of food intakes measured by unobtrusive, accurate weighed observations compare well with food records kept by the subjects over the same period, there is no guarantee that the observed intakes represent the usual diet (Block, 1982; Gibson, 1990). Since the truth is never completely known, validation studies compare one method with another method deemed to be superior (Willett, 1990). For this reason the term 'relative validity' is preferred (Livingstone, 1995; Margetts & Thompson, 1995). Another term used to refer to validation studies is 'calibration' (Buzzard & Sievert, 1994; Margetts & Thompson, 1995). Calibration, however, has been used more recently, specifically in relation to standardising methods between research centres and methods to adjust relative risk estimated from the main study for the measurement error associated with the use of food frequency questionnaires (Kaaks *et al.*, 1994a; Kaaks *et al.*, 1995; Carroll *et al.*, 1997; Kaaks & Riboli, 1997). In the present study, the term 'relative validity' will be used.

2.6.1 Dietary reference methods

Relative validation involves the comparison of a less established or less detailed method such as a food frequency questionnaire against a more detailed or more established method such as weighed records (Willett, 1990; Buzzard & Sievert, 1994). The more established method is assumed to provide more accurate estimates of food intakes within the study population (Buzzard & Sievert, 1994). In the past, the method against which a dietary assessment instrument was tested, was frequently referred to as a 'gold standard' (Willett, 1990). This implied that the reference method was perfect and measured the absolute truth. Since the recognition that no dietary assessment method is error free (Burema *et al.*, 1995), it has been suggested that the term 'gold standard' be avoided (Margetts & Thompson, 1995).

Given that neither the test nor the reference methods are perfect, it is important that the errors

of both methods be independent (uncorrelated) to avoid spuriously high estimates of validity (Willett, 1990; Livingstone, 1995). Thus, studies which compare the results of similar methods, for example a quantitative food frequency questionnaire and a diet history (Welton *et al.*, 1995), 24-hour recalls and diet history (Rasanen, 1979; Karvetti & Knuts, 1981; Smith *et al.*, 1986) or 24-hour recalls and food frequency questionnaires (Munger *et al.*, 1992; Dittus *et al.*, 1994; Romieu *et al.*, 1997) may not give an accurate reflection of validity. This is because the major sources of error such as memory, understanding of questions and perceptions of portion sizes are likely to be the same for diet histories, food frequency questionnaires and 24-hour recalls (Willett, 1990; Garrow, 1995). In the literature, it is also necessary to distinguish between studies which compare different dietary intake assessment methods and those which test the relative validity of one or more methods against a single reference method. For example, Sorenson *et al.* (1985) compared the results of a 24-hour recall, modified diet history, a two-day food diary and a food frequency questionnaire and Morgan *et al.* (1987b) compared several combinations of prospective and retrospective recording methods (personal, mail, telephone and telephone assisted reporting; semistructured and open-ended questionnaires and number and spacing of days of recording). Neither of these studies was testing the validity of the methods. On the other hand, the reports of Bingham and co-workers (1994) which compared the diet of 160 women estimated by a 24-hour recall; a structured 24-hour recall with and without photographs to indicate portion sizes; two types of food frequency questionnaires and a structured seven-day record without and without portion size photographs against a 16-day weighed record is an example of a relative validation study.

2.6.1.1 Duplicate food portions

Chemical analysis of foods which duplicate those eaten by a subject is theoretically the most accurate method of assessing dietary intakes as it makes allowance for deviation from the values in the food composition tables (Eyberg, 1985). The collection and chemical analysis of duplicate meals or food portions has been used in several studies as a reference for the relative validation of 24-hour recalls (Eyberg, 1985; Rider *et al.*, 1984) and weighed records (Rider *et al.*, 1984; Alberti-Fidanza *et al.*, 1994b). In these studies, subjects, or in the case of children, the carers, were asked to keep exact duplicates of the food they eat for one (Eyberg, 1985), two (Alberti-

Fidanza *et al.*, 1994b), three (Rider *et al.*, 1984) or seven days (Kim *et al.*, 1984). The composite food samples were then chemically analysed and the results compared to the results of the test measure. High correlation coefficients (greater than 0,89) have been obtained for energy, protein, fat, calcium and phosphorous (Eyberg, 1985; Rider *et al.*, 1984). The sample sizes in these studies, however, were small, 10 (Eyberg, 1985) and 18 subjects respectively (Rider *et al.*, 1984) and similar results may not be obtained for larger samples. In contrast, Alberti-Fidanza *et al.* (1994b) reported that intakes of protein and fat derived from duplicate portions were significantly lower than those calculated from diet histories on all measures in their longitudinal study. Kim and co-workers (1984) in a study in which 29 subjects kept daily food records for a year, have shown that the collection of duplicate food portions caused a significant decrease in the energy and nutrient intakes during the collection periods compared with the mean intakes for the years.

From a review of the studies which have used the duplicate food portion technique by Isaksson (1993), it is evident that the duplicate portion technique underestimates the habitual dietary intakes of the subjects. Possibly, the exact weighing of duplicate portions for a single day might produce more accurate results, but longer periods place an unacceptable burden on the respondents (Bingham, 1987). The duplicate meal method requires sophisticated equipment and laboratory facilities and the work load, for both the researchers and the subjects is high. Thus, the usefulness of this method in relative validation studies is limited.

2.6.1.2 Observation

Non participant observation has been used to validate 24-hour recall and diet history methods. Direct observation is usually only possible in institutionalised settings such as hospitals (Levine *et al.*, 1987; van der Ster Wallin *et al.*, 1995), community centres for the elderly (Madden *et al.*, 1976) and schools (Crawford *et al.*, 1994; Domel *et al.*, 1994; Baxter *et al.*, 1997b) where preplated meals are served or where subjects can be observed unobtrusively. This facilitates the weighing of food portions before serving and plate waste without affecting the subjects' normal food intake behaviour. Using unobtrusive observation, Levine and co-workers (1987) reported differences of within 20% for the weighed record compared to a standard diet history and a

computer-based system for assessing dietary intakes. In a study which compared nutrient intakes obtained by observation and weighing of the meals of 76 elderly subjects at a community centre and 24-hour recalls, Madden and colleagues (1976) found no significant differences between recalled and actual intakes the seven nutrients compared but found that the recalled energy intake was significantly lower than the actual intake. Recalled energy and protein intakes were found to be lower than actual intakes for a group of 11 to 14 year children observed at three camp meals and given a 24-hour recall interview the following day (Carter *et al.*, 1981). In contrast, Crawford and colleagues (1994), who compared the results of 24-hour recall, 5-day recall and 3-day food record techniques against direct observation of the lunch intakes of nine to 10-year old girls, found observed intakes to be lower than reported intakes, with the most marked differences between the 5-day food frequency questionnaire and the observed intakes. Of note in this study (Crawford *et al.*, 1994) were the high Spearman correlations obtained between the observed and 3-day food record intakes (mean=0,87) and the slightly lower correlation between the 24-hour recall and observed intakes (mean=0,62) but the very weak correlations with the food frequency questionnaire.

Although direct observation may give accurate information about an individual's dietary intake, it can best be achieved in a controlled environment. Therefore, it does not provide an indication of how well the assessment measure performs in free living populations (Dittus *et al.*, 1994). Several attempts to validate the 24-hour recall method by direct observation and precise weighing techniques in free living situations have been reported. Most of these studies have been for the dietary assessment of young children in developing countries (Ferguson *et al.*, 1989; Abdullah & Ahmed, 1993; Dop *et al.*, 1994a; 1994b; Ferguson *et al.*, 1994; Kigutha *et al.*, 1997), a small sample of boys (Stunkard & Waxman, 1981) and pregnant Malawian women (Ferguson *et al.*, 1995). In these studies, research assistants spent one or several days in the respondent's household and weighed all food and drink consumed by the subject for that period. Reported Spearman rank correlation coefficients have varied from low to moderate in some studies (Ferguson *et al.*, 1994) to high in others (Dop *et al.*, 1994a).

Direct observation has several disadvantages. First, only foods eaten in the presence of the research assistant can be measured, second, the presence of the observer may alter the normal

food behaviours of the subjects and third, it may be necessary to alter normal household practices to facilitate measuring. For example, in the studies of the Ferguson group (1989; 1994; 1995) subjects were asked to serve their food onto separate plates instead of eating from a common bowl as is the norm in those communities.

2.6.1.3 Dietary records

The most frequently used reference method in validation studies, particularly since the 1980's, has been the dietary record or diary. Dietary records are more practical to implement under free living conditions than the above methods and are not subject to the same sources of error as food frequency questionnaires, diet histories or 24-hour recalls (memory lapses, portion size estimation and the interpretation of questions) (Willett, 1990). Willett (1990) has suggested that, because errors associated with food frequency questionnaires and dietary records are largely independent, validity may be understated.

Dietary records may either be weighed using balance or diet scales (Nes *et al.*, 1992; Lindroos *et al.*, 1993) or estimated using household measures (Larkin *et al.*, 1989) or food photographs (Hankin *et al.*, 1991). In all these procedures, the subjects record the weight and description of the food in specially designed note books or diaries. To simplify recording, Bingham and co-workers (1994) have developed the PETRA (Portable Electronic Tape Recorded Automatic) scales which combine a tape recorder with an electronic scale which records both the verbal description and weight of the food on a cassette.

The number of recording days has varied from two days (Karvetti & Knuts, 1992) to 28 days (Hankin *et al.*, 1991). The recording period needs to be long enough to quantify all foods usually eaten but not so long that the accuracy of recording is decreased. There is general agreement among researchers who have analysed diet record results in terms of accuracy compared to the number of days of intake, that a seven day period is adequate to quantify the usual intake of energy and the macronutrients (nutrients consumed in large amounts every day), while longer periods are needed for nutrients, such as vitamin A and cholesterol, which are present in large amounts in some foods and are therefore consumed irregularly (Marr & Heady,

1986; Rosner & Willett, 1988; Nelson *et al.*, 1989; Hartman *et al.*, 1990). Hartman *et al.* (1990) have suggested that 14 and 21 days would be needed to measure the usual intake of cholesterol and vitamin A respectively. Using persistence measures on food record data of 100 female subjects, Morgan *et al.* (1987) demonstrated that the benefits of increasing the number of recording days declined markedly after the sixth day. Since longer periods of recording could result in loss of interest and accuracy by the subjects, Nelson and co-workers (1989) have suggested that the time of recording be split into shorter periods of three or four days with an interval between. As can be seen from Table 2.6 below, several researchers have done this (Block *et al.*, 1990; Nes *et al.*, 1992; Frost Andersen *et al.*, 1995; Goldbohm *et al.*, 1995; Männistö *et al.*, 1996). A recent article in which Stram and co-workers (1995) analysed published validation results in terms of fixed cost constraints, it was concluded that, in most settings, validation studies would rarely require more than four or five one-day diet records per subject. In order to account for seasonal variations in the usual diet, recording periods have been spread throughout the year in some studies (Sempos *et al.*, 1984; Block *et al.*, 1990; Hankin *et al.*, 1991; O'Donnell *et al.*, 1991; Rimm *et al.*, 1992). With regard to reproducibility, however, Jørgenson *et al.* (1992) found no significant differences between mean intakes derived from two seven-day weighed records kept a month apart.

Although diet records have been taken in the past to be the ideal measure of intakes, they too are subject to errors (see 2.4.4.2). This has been highlighted by the validation of energy and protein intakes against energy expenditure and urinary nitrogen. (To be discussed in detail in the following section). In a review of the validity of dietary records, Bingham (1991) has shown that both energy and protein intakes may be underestimated.

The validation of dietary assessment instruments has been extensively reviewed by Willett (1990) and Bingham (1991) and Nelson (1991). Table 2.6 summarises selected validation for food frequency questionnaire and diet history studies in which diet records were used as the reference measure since 1989. Unless otherwise indicated, Pearson correlation coefficients are given for unadjusted data.

Table 2.6: Summary of validation studies using diet records as the reference method since 1989

Author and year	Sample	Test method	Reference method	Correlation coefficient						
				Energy	%Prot	CHO	Fat	Fibre	Alcohol	Micronutrients (range)
Food frequency questionnaire and dietary records										
Larkin <i>et al.</i> , 1989	White males=64 Black males=43 White females=73 Black females=48	**SQFF (Picture sort)	16-day estimated record	0,41 0,23 0,43 0,26	0,41 0,3 0,36 0,40	0,57 0,52 0,57 0,24	0,44 0,23 0,39 0,35	-	-	0,09 (iron , black males) - 0,62 (calcium, white males)
O'Donnelle <i>et al.</i> , 1991	Adults age 18-65 years N=52 Males N=24 Females N=28	**SQFF ‡SA	4x 4-day weighed records at 1 month intervals	0,35 0,42 0,34	0,43 0,33 0,56	0,35 0,52 0,26	0,39 0,44 0,40	0,67 0,77 0,66	0,74 0,79 0,82	0,09 (sodium) - 0,66 (riboflavin)
Nes <i>et al.</i> , 1992	67-80 year old N=38	**SQFF ‡SA	14-day weighed record split into 4 periods	0,61	*0,65	*0,48	*0,66	0,6	0,7	0,31(vitamin C)-0,75(vitamin D)
Rimm <i>et al.</i> , 1992	Adult male health professionals N=127	**SQFF ‡SA	2x7 days, 6 month interval	0,27	0,22	0,40	0,42	0,45	-	0,28 (iron)- 0,77 (vitamin B6 with supplements)
Lindroos <i>et al.</i> , 1993	Obese and non-obese adults N=64	**SQFF ‡SA	4-day weighed record	0,45	0,44	0,43	0,47	0,45	0,7	
Thompson & Margetts, 1993	Adult smokers Males=122 Females=179	**SQFF ‡SA	10-day weighed record†	0,38 0,36	0,35 0,35	0,54 0,52	0,34 0,44	0,49 0,56	0,83 0,82	0,18(Vitamin A)-0,59(folate)
Bingham <i>et al.</i> , 1994	50-65 year females N=160	**SQFF ‡SA bOxford Cambridge	16-day weighed record (PETRA)†	0,52 0,32	0,43 0,13	0,55 0,41	0,55 0,35	0,55 0,33	0,90 0,89	0,24(potassium)-0,55(retinol).
Rothenberg, 1994	70-year old males and females N=76	**SQFF ¶IA	4-day estimated record	0,60	0,5	0,56	0,6	0,48	0,55	0,38 (vitamin D)-0,57 (thiamin)
Frost Andersen <i>et al.</i> , 1995	11th-grade boys & girls (mean age=17years) N=49	*QFFQ ‡SA	7-day weighed record: split into 4 plus 3 consecutive days one week apart	†0,51	0,48	0,46	0,57	0,35	0,63	0,14 (vitamin D)-0,57 (riboflavin)
Goldbohm <i>et al.</i> , 1994	Adult males & females N=107	**SQFF ‡SA	3x3 days estimated record	0,74 †0,70	0,61 †0,54	0,77 †0,72	0,72 †0,69	0,74 †0,68	0,86 †0,89	0,4(thiamin)-0,73 (calcium)
Männistö <i>et al.</i> , 1996	Adult females N=160	**SFFQ ‡SA	2x 7-day estimated record	0,23	0,23	0,25	0,3	0,3	0,8	0,17(thiamin)-0,48 (carotenoids)
Bonifacj <i>et al.</i> , 1997	Adult males & females N=87	*QFFQ ‡SA	4-day weighed record	0,4	0,29	0,25	0,39	0,36	0,75	0,19(carotenoids) - 0,63(vitamin E)

Author and year	Sample	Test method	Reference method	Correlation coefficient						
				Energy	%Prot	CHO	Fat	Fibre	Alcohol	Micronutrients (range)
Diet history and dietary records										
Borrelli <i>et al.</i> , 1989	230 elderly	Burke diet history	3 day weighed record	0,7	0,47	0,59	0,64	0,31	0,88	0,02 (Vitamin A) - 0,67 (iron)
Block <i>et al.</i> , 1990	Females 45-70 years Usual diet group N=102 Low fat group N=158	Semi-quantitative diet history ‡SA	3x4-day diet record* collected in year prior to DH	0,51	0,48	0,51	0,60	-	-	0,37 (vitamin A)-0,74 (vitamin C, including supplements)
				0,51	0,56	0,55	0,57			
Hankin <i>et al.</i> , 1991	Multi ethnic adults 45-75 years N=262 Males=128 Females=134	Quantitative diet history	4x 7-day estimated records†	-	0,59	-	0,62	-	-	0,5(Vitamin A, females) - 0,64(vitamin B6, males)
					0,49 0,66		0,50 0,69			
Euronut SENECA investigators, 1991	Elderly N=81	Modified diet history	3-day weighed record	0,62	0,56	0,55	0,48	0,78	0,72	0,18 (Vitamin A)-0,75 (Vitamin B6)
Petersen <i>et al.</i> , 1992	Adults 20-31 years N=75	Simplified diet history	4-day estimated record	†0,7	0,58	0,64	0,64	0,62	0,4	
Delcourt <i>et al.</i> , 1994	Non-insulin dependent diabetes mellitus patients Males= 31 Females=27	Modified diet history	3-day weighed & estimated record							
				0,62 0,43	0,46 0,16	0,57 0,29	0,52 0,18	0,54 0,03		
SENECA investigators, 1996	Elderly 74-79 years Males N=387 Females N=420	Modified diet history	3-day estimated record	0,64	0,62	*0,67	*0,66	*0,73	0,84	0,32(vitamin C, males)-0,72 (calcium, males)
				0,51	0,48	*0,59	*0,56	*0,63	0,85	

§ Abbreviations of nutrients: Prot:protein; CHO: carbohydrate; *QFFQ: quantitative food frequency questionnaire; **SQFF: semiquantitative food frequency questionnaire; ‡SA: self administered; ¶IA: interviewer administered; †Spearman rank correlation coefficient; *percent energy; ^b two FFQs were used, ^cit is not clear whether the diet record was weighed or estimated.

As was the case for the reliability studies, it is not really meaningful to compare results of the above validation studies with each other. Apart from differences in sample size and composition, both the test and reference methods varied considerably. Although most test methods were semiquantitative food frequency questionnaires, they varied in format, number of items and mode of administration. Reference methods also differed considerably in the number of record days, whether records were kept consecutively or split into short periods over a number of months and whether weights or household measures were used to quantify intakes. Nevertheless, it is worth noting that most of the correlation coefficients for energy and the macronutrients fall within the range of 0,2 to 0,6, with only approximately 25% showing stronger correlation of between 0,6

and 0.8. Also, correlation coefficients are similar irrespective of the number of days of diet record. Willett (1990), in his review of validation studies, noted that impressively high correlation coefficients were obtained in early investigations prior to 1970. Later studies, however, using larger sample sizes generally showed moderately strong correlations, similar to those reported in Table 2.6 (Willett, 1990; Nelson, 1991).

Also of note from the above table, is that correlation coefficients vary between subgroups in the same populations. For example, in the study of Larkin and co-workers (1989), the test measure appeared to correlate less well with the diet record for the black males and females compared to the white males and females. There appears to be little difference in correlation coefficients obtained for males and females in some studies (O'Donnell *et al.*, 1991; Thompson & Margetts 1993) while others have obtained higher values for females (Hankin *et al.*, 1991). Age, however, does not seem to affect correlations as the coefficients obtained for samples of elderly subjects fall into the same range and, in some cases are higher, than younger adults.

It is also important to note that relative validity varies among nutrients. Correlations for alcohol appear high in most studies. Energy adjustment appears to slightly increase the correlations between methods (Lindroos *et al.*, 1993; Thompson & Margetts, 1993; Männistö *et al.*, 1996; SENECA investigators, 1996). In contrast, the Euronut SENECA investigators in 1991 found that correlation coefficients were similar or smaller when related to energy intakes, with the exception of vitamin A.

2.6.1.4 Multiple 24-hour recalls

The use of 24-hour recalls as a reference in a validation study of a food frequency questionnaire is far from ideal, as the errors of both methods are likely to be correlated. Nevertheless, multiple 24-hour recalls have been used by several investigators in validation studies of food frequency questionnaires. In situations where subjects are illiterate or not highly motivated or where the costs of conducting a diet record study are too high, researchers may have no alternative than to use a series of 24-hour recalls (Willett, 1990; Smith *et al.*, 1996). Generally, correlation coefficients obtained when 24-hour recalls were used as the reference measure appear in a lower

range to those obtained with dietary records as the reference. Munger *et al.* (1992) who compared a food frequency questionnaire to five, 24-hour recalls in a sample of 44 female subjects, obtained coefficients varying from -0,16 (for pyridoxine from food sources alone, adjusted for energy intake) to 0,95 (total thiamin, adjusted and unadjusted for energy intake) with the macronutrient correlations in the range of 0,16 (protein adjusted for energy intake) to 0,63 (total fat, adjusted for energy intake). Margetts and co-workers (1989) in a large study of 433 adults, using single 24-hour records (for 80% of subjects) and 24-hour recalls (for 20% of subjects) obtained correlation coefficients varying from 0,15 to 0,36. Correlation coefficients within a similar range to those of diet records as reference (0,12 for Vitamin E to 0,44 for energy, fat and calcium) were obtained by Romieu and colleagues (1997) in their sample of 134 Mexican women. Dittus and co-workers (1994) tested a semiquantitative food frequency questionnaire designed to assess fat intake against 12 telephone administered 24-hour recalls (N=58). These authors found no significant differences between fat intakes obtained by the two methods. In addition, most of the subjects (62%) preferred the food frequency questionnaire. It would therefore seem that a larger number of days are required if the 24-hour recall technique is used as a reference in validation studies.

2.6.2 Biological indicators (biomarkers) of dietary intake

Until fairly recently, biochemical indices, or biomarkers, have been used primarily as indicators of the nutritional status of individuals. For example, protein status may be assessed by measurement of total serum protein or plasma amino acids or vitamin A status by serum carotene or retinol levels (Krause & Mahan, 1984). Recently, nutritional epidemiologists have recognised the usefulness of biomarkers as indicators of dietary intake (Willett, 1992; van 't Veer *et al.*, 1993). Biomarkers have several advantages over dietary intake studies:

- (a) Biomarkers are assumed to be objective, that is, they do not rely on memory, or the respondent's ability to express themselves and are free of biases introduced by the presence of the interviewers (Willett, 1990). It must be remembered, however, that these measures are also subject to errors of measurement and classification (Hunter, 1990; van 't Veer *et al.*, 1993). These errors, however, are not related to the errors inherent in

dietary intake assessment methodologies and have the added advantage of being reasonable independent between repeated measurements (Plummer & Clayton, 1993b).

- (b) Biomarkers are not dependent on knowledge of food composition or source (Willett, 1992; van 't Veer *et al.*, 1993). Biomarkers may be the most reliable indicators of nutrients which vary widely such as selenium (Hunter, 1990).
- (c) They can account for individual differences in bioavailability, absorption and metabolism of nutrients (Willett, 1992).
- (d) When used together with dietary intake data, biomarkers can be used to justify and interpret dietary data as well as to show the effects of intake on the dietary marker (van 't Veer *et al.*, 1993; Connor, 1996).

Biomarkers have two functions as dietary indicators (Willett, 1990). First, as surrogates for actual dietary intakes or to complement dietary intake data in studies of disease occurrence. Second, since biomarkers are not subject to the same errors as dietary intake instruments, they may be used to validate other forms of dietary assessment (van 't Veer *et al.*, 1993). The use of biomarkers as substitutes for dietary intakes have been described by a number of authors including Hunter (1990) and Bates *et al.* (1991). The Proceedings of the Third Meeting on Nutrition Epidemiology (Kok & van 't Veer, 1991) provide a comprehensive overview of biomarkers as indicators of dietary intakes. Laboratory analyses of blood, urine, adipose tissue, stools, nails and hair have resulted in several biomarkers which may have limited use in assessing dietary intakes (Thompson & Byers, 1994). Although biomarkers appear to be objective measures of long-term exposures, the lack of information about storage and turn over rates of nutrients in body tissues has limited their usefulness in epidemiological studies (Kohlmeier, 1993).

A more important role of biomarkers, however, has developed in their use in validation studies (van 't Veer *et al.*, 1993; Kohlmeier, 1993). This section will focus on biomarkers in the validation of other dietary assessment methods.

2.6.2.1 Energy expenditure

One of the most basic principles of physiology is that for healthy individuals in energy balance, energy intake is equal to energy expenditure (Goldberg *et al.*, 1991). Thus, the comparison of energy expenditure with energy intake derived from dietary data should provide a means of validating reported energy intakes. Until fairly recently, this principle was difficult to apply in free living individuals. Energy expenditure could be measured only by calorimetry techniques. In addition to being very expensive, these techniques restrict normal activity patterns and so underestimate normal energy expenditure (Black *et al.*, 1993). Visser and co-workers (1995) compared physical activity diaries kept by 12 elderly women while in a respiratory chamber with diaries kept of free living activities and found that normal energy expenditure was considerably higher.

During the 1980's advances in the doubly labelled water (DLW) technique made it possible to apply this technique to the study of human energy expenditure under free living conditions (Black *et al.*, 1993). With the DLW technique, the subject takes one oral dose of isotope-labelled water ($^2\text{H}_2^{18}\text{O}$) and collects a single daily urine sample for the duration of the study period (Bingham, 1994; Black *et al.*, 1993). The burden to the subject and interference with normal activity patterns is minimal (Black *et al.*, 1993). Energy expenditure of adults can be measured for 14 days or longer (Black *et al.*, 1993), thus providing a measure of habitual energy expenditure (Goldberg *et al.*, 1991). In their review of DLW studies between 1986 and 1992, Black *et al.* (1993) have shown that there is good agreement between mean energy intake and energy expenditure when intakes were recorded by trained observers or by motivated, normal weight adults. In randomly selected adult samples, however, mean energy intake derived from weighed records varied between 61% and 82% of the measured energy expenditure.

Although the DLW technique may be very convenient to use, it is very expensive and requires specialised equipment and trained technicians, putting it beyond the means of most researchers (Bingham, 1991). A more practical method of estimating total energy expenditure (TEE) is by calculating basal metabolic rate (BMR) from weight and height data using the Schofield equations (Schofield, 1985) and multiplying by a factor representing the physical activity level

(PAL). According to the 1985 FAO/WHO/UNU report on energy and protein requirements, a PAL of 1,27 is the minimum for survival and a PAL of 1,55 is the minimum for a sedentary lifestyle (Goldberg *et al.*, 1991). Based on a review of studies on total energy expenditure measured by DLW, Black and co-workers (1996) have suggested the PAL factors for various lifestyles (Table 2.7).

Table 2.7 Relationship between activity and physical activity level (PAL) (Black *et al.*, 1996)

Activity level	*PAL
Chair or bed bound	1,2
Seated work with no option of moving around and little or no strenuous leisure activity	1,4 - 1,5
Seated work with moving around but little or no strenuous leisure activity	1,6 - 1,7
Standing work	1,8 - 1,9
Significant amounts of sport or strenuous leisure activity	+ 0,3
Strenuous work or highly active leisure	2,0 - 2,4

*PAL= physical activity level

The ratio of BMR to energy intake (EI) is used to express the agreement between reported energy intake and BMR. If the EI:BMR ratio falls below a given cut off value, the reported intake may be suspected of being an underestimation. Very low EI:BMR ratios may indicate that the reported intake is incompatible with health and normal body weight (Black *et al.*, 1993; Goldberg *et al.*, 1991). Goldberg and colleagues (1991) have derived a series of cut off values to identify implausible intakes for both DLW and calorimetry measured energy expenditure and estimated BMR and for habitual intakes and intakes at the time of the study. These authors have concluded that EI:BMR ratios below 1,35 for measured BMR and 1,55 for estimated BMR are likely to reflect underreporting of energy intake. In a review of 37 studies between 1977 and 1991 in which the EI:BMR ratio was used to test the validity of reported energy intakes, Black *et al.* (1993) have shown a mean EI:BMR of 1,43 compared to 1,55 expected for a sedentary lifestyle. Table 2.8 summarises EI:BMR ratios obtained in studies since 1990.

Table 2.8: Summary of *EI:BMR ratios

Study	Population	Sample size	Dietary assessment instrument	Mean *EI:BMR	Cut off *EI:BMR	% Below cut off	Comments
Livingstone <i>et al.</i> , 1990	Males 17-46 years Females 20-50 years	16 15	7-day weighed record	1,49 1,43	1,3		BMR measured by DLW
Nes <i>et al.</i> , 1992	Females 67-80 years	38	14-day weighed record	1,45	1,17	18	BMR measured by indirect calorimetry
Haraldsdóttir & Sandström, 1994	Males 20-30 years Females 20-30 years	48 22	7-day weighed record	1,92 1,77		6	Strictly controlled dietary intervention
Rothenberg, 1994	Males 70 years Females 70 years	34 42	**SFFQ 4-day estimated record **SFFQ 4-day estimated record	1,72 1,28 1,58 1,26	1,47 1,46 1,48 1,46		**SFFQ was interviewer administered
Wheeler <i>et al.</i> , 1994	Adult males and females	242	Meal-based **SFFQ	1,17-1,35		19-29	Three different formats of SFFQ used
Bingham <i>et al.</i> , 1995	Adult females	156	16-day weighed record	1,15-1,54			Data collected over one year
Hulshof <i>et al.</i> , 1995	Adult Turkish immigrants	69	Repeated dietary recalls	1,34			
Klesges <i>et al.</i> , 1995	Adults 18 - 74 years	11663	24-hour recall		1,2	54	0,92 - 1,2 borderline underreporters =23%
Cole <i>et al.</i> , 1997	Nigerian females 11-17 years	22	Weighed records by observers	1,2	1,2	41	
Hirvonen <i>et al.</i> , 1997	Adults males 1982 Females 1982 Adult males 1992 Females 1992	2267 2822	3-day estimated record		1,27	27 33 42 46	Comparison of underreporting over 10 years
Macdiarmid & Blundell, 1997	Males Females	48 52	7-day weighed record	1,23	1,5		Subjects asked about changing eating habits
Price <i>et al.</i> , 1997	Adult males Adult females	960 938	7-day estimated record	1,39 1,36	1,10	18,5 22,7	

Rothenberg <i>et al.</i> , 1997	Elderly males Elderly females	369 440	Diet history	1,50 1,48	1,20	22 28	
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*EI:BMR: Ratio of energy intake to basal metabolic rate; **SFFQ: Semiquantitative food frequency questionnaire;
¶ Median

The above estimates of PAL (Table 2.7) and of EI:BMR (Table 2.8) provide guidelines for the assessment of the validity of reported energy intakes. It must be born in mind, however, that most of these values have been derived for affluent western populations (Black *et al.*, 1996) and the application to other populations must be done with caution (Huss-Ashmore & Curry, 1991; Case *et al.*, 1997; Cole *et al.*, 1997; Piers *et al.*, 1997). The ratios obtained for the food frequency questionnaire were similar, and in some cases higher, than those obtained for weighed or estimated records. Researchers need to determine the most appropriate cut off points for the specific population based on sample size and general activity pattern of the group (Black *et al.*, 1991).

Several studies have compared energy intakes directly with total energy expenditure. Visser *et al.* (1995) found that energy expenditure measured in a respiratory chamber by indirect calorimetry was significantly higher than energy intakes reported by diet histories in a group of elderly women. Using four different dietary intake assessment methods (seven-day weighed record, 24 hour recall, and two food frequency questionnaires), Sawaya *et al.* (1996) reported lower energy intakes than energy expenditure measured by DLW by all methods in a group of 20 women. Similar results were obtained by Black and co-workers (1995) in their study in which they compared total energy expenditure measured by DLW to energy intake derived from weighed records for a 21-day period and two diet histories in 11 post-obese subjects. These researchers found a mean ratio EI:TEE of 0,76 (SD=0,27) for the weighed records while the ratio for the diet histories were below 1,0 for all subjects (mean not reported). Comparisons of reported energy intakes with energy requirements to maintain weight have shown that most reported energy intakes fall below these requirements (Bolton-Smith, 1991; Mertz *et al.*, 1991; de Vries *et al.*, 1994; Price *et al.*, 1997). Livingstone *et al.* (1992) reported higher EI:TEE ratios (TEE measured by DLW) for diet histories (0,98 to 1,14) than for seven-day weighed records (0,73 to 1,08) for children aged between seven and 18 years. The difference was most marked among the adolescents, leading to the conclusion that the diet history method was a more valid measure of energy intake in this age group than the keeping of weighed dietary records.

2.6.2.2 Urinary nitrogen

The use of 24-hour urinary nitrogen excretion to assess the validity of reported protein intakes is based on the principle that, for healthy adults in nitrogen balance, nitrogen intake will be equal to nitrogen excreted in the urine and lost in sweat and faeces (Bingham, 1991). Dietary intake is taken to be valid if the urinary nitrogen is between 75% and 85% of the dietary nitrogen (Bingham *et al.*, 1992). In 1980, Isaksson reported several studies that showed that estimates of protein intake obtained from 24-hour recalls were lower than protein calculated from urinary nitrogen but that intakes obtained from diet histories and food records were closer to the urinary results. Early studies using 24-hour urinary nitrogen to validate estimated protein intakes showed inconsistent results, being greater than intake estimates in some cases while showing good agreement in others (Bingham, 1987; Bingham, 1994). Inconsistencies in the results of urinary nitrogen collections were ascribed partly to the incomplete collection of urine over the 24-hour period (Knuiman *et al.*, 1986; Bingham, 1994). Therefore, ways in which to ensure that complete 24-hour collections had been made were investigated. Initially, urinary creatinine was used as a measure of completeness of collection. Urinary creatinine excretion, however, has been found to be an insensitive measure of completeness (Bingham, 1994; Knuiman *et al.*, 1986). Bingham and co-workers have developed and standardised the use of *para*-amino benzoic acid (PABA) as a measure of completeness of urinary sample collection (Bingham & Cummings, 1983; Bingham *et al.*, 1992; Bingham *et al.*, 1995). PABA is a component of folic acid, safe to use in human populations, absorbed from the gastro intestinal tract by simple diffusion, not affected by diet and excreted as *para*-aminohippuric acid (PAHA) in the urine (Bingham & Cummings, 1983; 1986). The method consists of three 80-mg tablets of PABA (total 240 mg) taken with meals during the day of urine collection. Subjects are given two 2 l bottles in a canvas bag, a safety pin to attach to their underwear as a reminder, instruction sheets and a sheet for recording the times at which specimens were collected (Bingham & Cummings, 1983; 1986). The PABA content of the urine specimens is measured by paper chromatography (for a detailed description of the analytic method, see Bingham and Cummings, 1983). Specimens which contain 85% or more PABA are taken as complete (Bingham, 1991). The use of PABA, however, itself has limitations. Subjects may forget to take one or more of the tablets, they may not take the tablets at the correct times, may fail to record urine specimens or may fail to collect specimens (Knuiman

et al., 1986; Knuiman & Hautvast, 1986). Losses of PABA may occur during storage or analytical techniques may underestimate PABA or the urine may be contaminated with paracetamol or B-vitamin preparations (O'Donnell *et al.*, 1991). The importance of confirming that urine collections are complete has been demonstrated by the fact that analysates from incomplete samples may be as much as 30% lower than analysates from complete samples (Bingham, 1991; Bingham *et al.*, 1992; Bingham *et al.*, 1995).

Reported correlations between urinary nitrogen and dietary nitrogen vary considerably depending on the type of dietary assessment method used, number of days of urine collection and completeness of urine collections. Under metabolic unit conditions, Bingham and Cummings (1985) obtained an average correlation of one over a 28-day study period for eight highly motivated subjects. Daily correlations, however, varied between 0,16 and 0,74. O'Donnell *et al.* (1991) reported a correlation of 0,56 (N=52) for 8-day urine collections compared with 16-day weighed records, but 65% of the collections were incomplete. Porrini *et al.* (1995) reported a correlation of 0,77 (N=44) for seven-day weighed records and three 24-hour urine specimens. In a sample of 76 elderly subjects, Rothenberg (1994) obtained a correlation coefficient of 0,47 between a four-day estimated diet record and four 24-hour urine specimens. Bingham and co-workers (1995) compared seven dietary intake assessment methods over a one year period and found that the highest correlations were obtained between 16-day weighed records (0,69; N=156) and seven-day estimated records (0,65; N=63). Weakest correlations were obtained for 24-hour recalls (0,1 and 0,21 for unstructured and structured recalls respectively). Correlations of 0,15-0,24 (Bingham *et al.*, 1995), 0,19 (Rothenberg, 1994) and 0,46 (Porrini *et al.*, 1995) have been reported for food frequency questionnaires. Jørgenson and co-workers (1992) found no significant difference between the mean protein estimated from urine samples (74,7 g SD=15,9) of 40 subjects and the mean protein intake obtained from a semiquantitative food frequency questionnaire.

2.6.3 Statistical methods

The realisation that the correlation coefficient may not be an appropriate measure of agreement between dietary intake measurement instruments (Hebert & Miller, 1991; Delcourt *et al.*, 1994;

Bellach, 1993) and that there is no true 'gold standard' against which an instrument can be validated (Borrelli *et al.*, 1989; Willett, 1990; Beaton, 1991; Mertz, 1992) has led several researchers to investigate alternative methods of analysing validation study data. Although a discussion of these methods is beyond the scope of this thesis, a brief overview of some of these methods will be given. More detailed descriptions of the methods applicable to the present study are given in Chapter 5 (Methods), Chapter 6 (Reproducibility) and Chapter 7 (Relative validation).

In 1986, Bland and Altman proposed a method of analysing validation data in clinical studies whereby the difference between measurements obtained on two instruments was plotted against the mean of the two methods. From this plot, the relationship between the measurement error and the 'true' intake (estimated by the mean of the two methods) can be investigated. Based on the assumption that the differences follow a Normal distribution, 95% of the differences can be expected to lie between the mean minus two standard deviations and the mean plus two standard deviations, known as the limits of agreement. This fairly simple technique has been applied to dietary intake validation studies by, among others, Thompson and Margetts (1993), Saba *et al.* (1995), Robinson *et al.* (1996) and Körtzinger *et al.* (1997) to investigate the presence of bias and the extent of agreement between measurement instruments.

Several authors have investigated ways of estimating within and between person variance (Sempos *et al.*, 1985; Beaton, 1991; 1994; Bellù & Cucco, 1997) while others have applied structural equation models to validation data, with and without the inclusion of a biomarker (Plummer & Clayton, 1993a; 1993b; Kaaks *et al.*, 1994b). Other techniques include correcting for measurement error (Keiding, 1993; Spiegelman *et al.*, 1997) controlling or adjusting for energy intakes (Flegal *et al.*, 1988; Flegal & Larkin, 1990; Martin-Moreno, 1993; Palmgren, 1993). The most recent techniques, using a combination of reference methods and biomarkers, known as the 'method of triads' have been described for the EPIC (European Prospective Investigation into Cancer and Nutrition) project (Kaaks & Riboli, 1997; Ocké & Kaaks, 1997).

2.7 SUMMARY AND CONCLUSION

This chapter has attempted to provide the theoretical background on which the remainder of the thesis is based. First, by describing the historical background and the process of transition of the African population of the North West province, it set context in which the study was undertaken and established the need for a study on the effect of urbanisation on dietary intakes. Second, it highlighted the need for the development and use of culture-sensitive dietary intake measurement instruments and visual aids for use in the specific population. Third, it dealt with the various types of dietary intake assessment instruments available and most important, the need to establish the reproducibility and relative validity of such instruments. In the chapters that follow, this theory will be applied to the development, testing and implementation of a quantitative food frequency questionnaire and food portion photograph book for the study of the dietary intakes of the African population of North West province.

CHAPTER 3

PRELIMINARY STUDY ON FOOD HABITS, MEAL PATTERNS AND FOOD PREPARATION METHODS

3.1 SUMMARY

The preliminary study was undertaken to collect information on the food related behaviours and food habits of the population of the North West province. The study was conducted in two phases using a combination of qualitative and quantitative approaches. In the first phase, in depth interviews were conducted with a total of 32 participants from rural, farm, informal settlement, and urban middle and upper class areas. Information was collected on procurement, frequency of consumption, preparation and serving methods of common foods. The most frequently mentioned foods were then prepared following the instructions of the participants and presented to five focus groups (the second phase). The focus groups either confirmed the preparation methods or corrected the researcher's misconceptions.

The results showed that the food habits of the participants in the rural, farm, informal settlement and urban middle class areas were similar. Maize meal, prepared in a variety of ways, was the staple food; chicken was eaten more frequently than red meat and fruit and vegetables were consumed in small amounts. The participants in the urban upper class area consumed a wider variety of foods. Maize meal was used less frequently and replaced by other cereals such as rice and pastas. Fruit and vegetables were consumed more frequently and in larger amounts. Despite a number of shortcomings, the results of the preliminary study provided the information necessary for the development of the quantitative food frequency questionnaire (QFFQ) and the food portion photograph book (FPPB).

3.2 INTRODUCTION

3.2.1 Background to the preliminary study

Dietary intake and food habits are an integral part of the culture of a population (Cassidy, 1994). The need for dietary intake measurement instruments which are sensitive to the culture of the target population has been stressed by several authors (Krall *et al.*, 1988; Wahlqvist *et al.*, 1991; Buzzard & Sievert, 1994; Cassidy, 1994; Hankin & Wilkens, 1994; de Castro, 1997). In the present study, not only was a culture group, but also the different strata of urbanisation within that population, studied. This meant that the same dietary intake instrument had to be applicable and relevant to the five strata of urbanisation. According to the literature before such an instrument can be developed, information both on the lifestyles, environment, facilities and food preparation methods of the population, and of the meanings attached to food are needed (Cassidy, 1994; Benavente & Pobocik, 1997; Campbell *et al.*, 1997; Hernández *et al.*, 1997). In order to gain an understanding of the food habits of the target population, a preliminary study, using a combination of qualitative and quantitative methodologies was undertaken from September to November 1995.

A qualitative approach was taken in collecting the necessary background information for the following reasons:

- (a) Qualitative approaches do not set out to test a hypothesis or theory as do quantitative research methods, but rather to develop a theory inductively from the data (Field & Morse, 1992; Denzin & Lincoln, 1994). Qualitative data are also useful in providing frameworks for the development of quantitative measurement instruments (Stewart & Tinsley, 1995). At the outset of the present preliminary study, the food habits and the social and cultural meanings attached to food by the target population were unknown to the researcher. Therefore, methods that could collect and analyse data with which to develop a framework for the development of a culturally sensitive food intake measurement instrument were needed.
- (b) Qualitative research approaches study the participants of the study in their natural setting

(Field & Morse, 1992). That is, the researcher meets the participants in their own homes and familiar surroundings, in contrast to the more traditional quantitative dietary intake methods where the subjects come to the researcher. This enables the researcher to observe the participants' home environments and thus to see food habits within the context of the participants' normal every day lives.

- (c) Although both quantitative and qualitative research approaches are used to collect data from the individual, qualitative research, using detailed interpretive interview and observation methods, is better able to get close to the participant's perspective and to collect rich descriptions of the participants' food intake behaviour (Denzin & Lincoln, 1994; Stewart & Tinsley, 1995).
- (d) Qualitative research uses a combination of methods, rather than a single method to collect data. This combination of methods, or triangulation, adds rigour to the data collection and ensures that a deep and true understanding of the phenomenon being studied, is achieved (Denzin & Lincoln, 1994).
- (e) An advantage of qualitative research is that it allows for changes to be made during the research process based on data already generated (Denzin & Lincoln, 1994). Thus, the research process is flexible and allows the researcher to adapt the interview schedule according to responses already given.

3.2.2 Aims

The overall objective of the preliminary study was to collect information needed to develop the food intake measurement instrument and food portion photograph book (FPPB) for use in the dietary intake study and to acquaint the researcher with the study area.

3.2.2.1 Specific objectives

- (a) To use qualitative research methods to ascertain the ways in which the African population of the North West province describe the types, preparation and serving methods of foods they commonly eat.
- (b) To determine, by using quantitative research methods, the foods most frequently consumed by the African population of the North West province and the typical portion sizes of these foods.
- (c) To describe the utensils used for the measuring, preparation and serving food
- (d) To become acquainted with the environment, living conditions and food related behaviours of the population living in the different strata of urbanisation (see 3.3.1.1 below).

3.2.3 Delimitations

- (a) The preliminary study was concerned only with the types, serving sizes and preparation methods of foods consumed and therefore did not include nutrient analyses or assessment of the quality of the diets.
- (b) The preliminary study gathered information on individual and household food consumption and not on food consumption in institutions.

3.2.4 Importance of the preliminary study

The information collected by the preliminary study was necessary for the development of a culture-sensitive QFFQ and the FPPB.

3.3 METHODS

3.3.1 Sample selection

3.3.1.1 Identification of study areas and participants

As pointed out in Chapter 1, one of the purposes of the present study was to describe the effect of urbanisation on the dietary intakes of the African population of the North West province. To achieve this, the population was classified into five levels, or strata of urbanisation, as follows:

- (a) rural dwellers
- (b) farm workers on white owned farms
- (c) informal settlements dwellers
- (d) middle class urban dwellers
- (e) upper class urban dwellers

In order to collect relevant information, communities corresponding to each of the above strata were identified for the preliminary study. Areas to which the researcher could gain access through influential 'gate keepers' or persons who knew the communities well and had contacts within the communities were selected by convenience sampling. Within each area a combination of sampling methods was used to identify participants. This took the differences among the strata into account and allowed for greater flexibility (Field and Morse, 1992).

The areas selected and the ways in which participants were identified in each stratum are described in detail below.

(a) Rural stratum

The village selected for the preliminary study was Moshawane. It is situated approximately 285 km north west of Potchefstroom, 70 km south west of Mmabatho and 300 km from Rustenburg. The area surrounding the village is arid. The nearest small towns are Setlagole, about 50 km from the village and Sannieshof approximately 80 km away (Figure 3.1). The village fell under a tribal authority, this being the criterion used to define 'rural' for the main study. The headman of



Figure 3.1: The North West province (1995)

Moshawane was contacted through the Pastor of the Dutch Reformed Church in Sannieshof which supports an evangelist who works with the community of Moshawane. The evangelist accompanied the researcher and her assistant to the village, to introduce them to the community and to gain permission before interviews were conducted. At this meeting, the purpose of the study was explained. The wife of the headman was asked to identify possible participants (snowball sampling) (Field & Morse, 1992) and appointments for the interviews were set.

All houses visited were made from bricks, although some of the other homes in the village were made from corrugated iron and/or mud. There was no electricity or running water supply. Heating and fuel sources were chiefly paraffin and wood. Water was obtained from a communal windmill pump situated near the small primary school. The larger houses had separate kitchens, while in the smaller houses the eating, living and cooking areas were combined. Although there were paraffin (kerosene) hot plates (*primus*) or coal stoves in some of the homes, most cooking, especially of porridge and stews, was done in three-legged cast iron pots on open fires in an outside *lapa*, an area surrounded by a semicircular wall of reeds to shelter the fire from wind. Cooking was done inside in cold or rainy weather.

Food supplies were obtained from the nearest towns, Mmabatho and Delareyville, usually on a monthly basis. There were several small shops, known as *spazas* or tuck shops which supplied essentials such as canned fish, sugar, meat, Holsum, sweets and cleaning materials and toiletries. Most of the men of the village were employed in Rustenburg or Mmabatho.

(b) Farm worker stratum

Contact was made with three farmers through persons at Potchefstroom University for CHE who know them. All were white owned farms. Two of the farms were dairy farms situated at Barberspan in the Delareyville district and the other was a mixed farm at Fochville, situated approximately 30 km north of Potchefstroom (Figure 3.1). All were white owned farms where workers live in houses provided by the farmers.

The researchers met each farmer's wife to describe the purpose of the study and to make arrangements to interview the wives of the farm workers. Convenience sampling was used to

select participants, that is, all the women living on the farm and available on the day of the interviews were included in the sample (Stewart & Shamdasani, 1990).

Housing was provided by the farm owners for the workers and their families. All houses were made of bricks and supplied with electricity. Water was provided from the farm at outside taps at all the houses and inside taps in three of the houses.

(c) Informal settlement stratum

Contact with participants in Top City, the informal settlement next to Ikageng and Potchefstroom (Figure 3.1) was made through an employee of the Department of Nutrition and Family Ecology at PU for CHE who lived in Top City. As in the case of Moshawane, snowballing was used to generate the sample. The employee became the key informant and introduced the researcher to neighbours who were willing to participate in the study.

The informal settlements visited were Top City and adjacent areas known as Kanana, Skielik and Serafina, which border on Ikageng. Although the main road from Potchefstroom through Ikageng to Top City was tarred, other roads were dirt. The houses in the informal settlements were mostly made of corrugated iron. There was no electricity supply at the time of the study, so that most households depended on paraffin (kerosene), coal or wood as light and heat sources. Running water was not available in the houses but was supplied by outside taps.

(d) Middle class urban stratum

Ikageng was the town selected as the urban middle class area. It is an African township with a population of approximately 55000 people (Fenn *et al.*, 1995), adjacent to Potchefstroom (Figure 3.1). The reasons for selecting Ikageng were its proximity to the PU for CHE and the fact that the Department of Nutrition and Family Ecology already had contact with the Ikageng Community Development Committee. Permission to conduct the preliminary studies in Ikageng, Top City and Kanana was sought and obtained from the chairperson of the Ikageng Community Development Committee. He put the researchers in contact with his sister. She, in turn, introduced other participants living in Ikageng and Kanana (snowball sampling) (Field & Morse,

1992).

The town had an infrastructure of electricity, water and sewage supplied by the Municipality. Houses are built from brick and most have gardens. Many of the homes had telephones. Main roads through Ikageng were tarred, but most subsidiary roads were dirt. There was no clear boundary between Ikageng and the adjacent informal settlement areas.

(e) Upper class urban

Mmabatho, (adult population: 17722) (National Democratic Institute, 1996) the capital of the North West Province, was identified as the area in which to contact participants from the upper class urban stratum. Contact was made through a lecturer in the Biology Department of the University of the North West. Critical case sampling, that is the identification of persons who could give rich and detailed information (Field & Morse, 1992) was used to select participants.

Mmabatho is an established city with a developed infrastructure of municipal services and tarred roads. The homes of all participants were permanent brick structures, most with gardens. The city has well developed shopping, entertainment and sporting facilities. Many of the citizens were professionals, executives and government employees.

3.3.1.2 Selection criteria

Participants who met the following criteria were included in the sample:

- (a) adult African females
- (b) resident in the area and with a good knowledge of the area
- (c) responsible for the food procurement and preparation for their households
- (d) able to communicate in Tswana

3.3.1.3 Sample size

The desired sample size was 30 participants (six participants from each stratum).

3.3.2 Data collection

A combination of qualitative and quantitative research methods were used simultaneously and sequentially to collect data in the preliminary study.

3.3.2.1 Interviews

The first step of data collection was interviewing participants using a semistructured interview schedule to collect both qualitative and quantitative data (Appendix A). Interviews were conducted at the participants' homes in Tswana by a Tswana speaking interviewer and in the presence of the researcher. The purpose of the study and interview procedure was explained to the participants and permission to tape record the interview was requested. The qualitative and quantitative data was collected simultaneously. All the interviews were tape recorded.

In order to make the description of foods and recipes easier for the participants, actual foods were shown at the interviews. Foods used included: raw cabbage (cut into a half (800 g) and a quarter (400 g)), raw pumpkin cut into blocks, potatoes, onions, tomatoes, carrots (whole and sliced), raw maize meal, cooked stiff maize meal porridge, raw and cooked samp, raw and cooked dried beans, small and medium sized cans of pilchards, cooked chicken portions, cooked meat cubes, French polony, atchar, brown bread, hard yellow margarine, vegetable cooking fat (Holsum), sunflower oil, salt, sugar and bread flour.

(a) Qualitative data collection

Initial questions were asked to obtain background information on the household such as the number, ages and gender of household members, the extent of acculturation and the environment. Participants were then asked to describe a typical day's food intake. Participants were also asked to describe how they prepared, cooked and served foods. Actual foods were used to aid in the description of portion sizes and food preparation methods. For example, a participant describing the preparation of cabbage, would indicate the amount of cabbage, select the potatoes and other

vegetables (such as tomatoes and onions) she would add, pour the amount of oil or cut a piece of fat, and show the amount of salt she would use. The interviewer wrote the participants' descriptions onto the interview form and the interviews were tape recorded for later translation and transcription.

Participants were then asked to describe how they served food, who ate the food and how their food intake varied between week and weekend days.

Observation is another method used in qualitative studies to collect data (Field & Morse 1992). Thus, the researcher observed and made notes about the environment such as the type of house, water supply and garden as well as on the reactions of the participant during the interview.

(b) Quantitative data collection

The quantitative aspect of the interviews involved asking the participants to show the utensils such as cups, spoons and dishes, used for measuring and serving food. The capacities of these utensils were then measured. The amount of food indicated by the participants when they described their food preparation methods were weighed (solids) or the volume measured (liquids) and recorded on the interview schedule.

Initially participants were asked to serve out the amounts of porridge, bread and meat usually eaten by members of the household. However this took too much time and after the first 10 participants, portion sizes were shown to the participants and they indicated which would be a typical serving.

Photographs were taken of the environments, foods and participants. Each subject was given a token of appreciation (a packet of dried beans) after the interview. Each interview took approximately 90 minutes to complete. At the end of the interview the participants were asked whether they would be willing to participate in a focus group in six to eight weeks time.

3.3.2.2 Focus groups

An essential element of qualitative research is quality control to ensure the integrity of the data collected. This is done by triangulation, the use of two or more methods of data collection and analysis (Denzin & Lincoln, 1992). At first, both qualitative and quantitative data was collected by interviews and observation (two methods) and recorded both in writing and on audio tape (two methods). These data were then analysed and corrected or confirmed by focus group discussions.

A focus group is a small number of individuals meeting together under the moderation of a facilitator to discuss a specific issue (Stewart & Shamdasani, 1990). Focus groups are useful at various points in the research process. Early in the research process they are used to explore a phenomenon about which little is known. As group interviews they are used for data collection. Following data collection by other methods, they may be used to confirm and add depth to data and to interpret previously obtained data (Stewart & Shamdasani, 1990). In the present preliminary study, focus groups were used to confirm or correct the researcher's interpretation of the data collected during the interviews, and to add depth to the data already obtained.

After the analysis of the data on foods and recipes obtained from the interviews, average recipes for the most common dishes were calculated (see 3.3.3 Data analysis). These recipes were then prepared for presentation to the focus groups for discussion.

For practical purposes, not all recipes were presented to all the groups. Recipes specifically made by the participants in that area were presented to the specific groups. For example, chicken bone stew was only mentioned by participants in Top City, and was therefore only presented to this group; atchar and polony were only presented to the Ikageng and Top City groups as these were the participants who mentioned them. Dishes common to all areas, eg cabbage, pumpkin, spinach, beef and chicken were presented to two or three groups. Since stiff maize meal porridge and samp and beans made a large contribution to the diets in all areas, these two dishes were presented to all the groups. The dishes presented to each group are given in Appendix B.

Gaps in the information obtained from the interviews were identified and used as a basis for the focus group discussions (Appendix C).

Prior to the focus groups, the key informant in each area was contacted and asked to arrange a time and place to meet with the other participants in that area. In the case of the farms, the arrangements were made through the farmers' wives. In Moshawane, the arrangements were again done by the evangelist.

Focus groups were held in all strata except the upper class urban stratum in Mmabatho. The reason for this was practical difficulty in arranging a time that suited all the participants.

Focus group procedure

The discussions followed the discussion outline (Appendix C) and were facilitated by the same Tswana speaking research assistant who conducted the interviews. All discussions were recorded during the focus group and later transcribed and translated by an independent interpreter.

The procedure was as follows:

- (a) The facilitator welcomed the participants and explained the purpose of the meeting.
- (b) Each dish was presented to, and tasted by, the group members. Participants commented on the appearance and taste of the food and gave suggestions for improvements. Although most of the discussion was in Tswana and the researcher was an observer, sometimes the participants asked the researcher directly about how she had prepared the food and the researcher questioned the group for clarification of food preparation methods.
- (c) Questions relating to the storage and serving of meals were discussed.
- (d) Participants were asked to dish a typical meal for a man, a woman and a child.
- (e) The researcher and assistant weighed the servings while the participants had refreshments.

The focus groups took about 90 to 120 minutes to complete and each participant was given a

small token of appreciation.

As pointed out in the introduction to this chapter, qualitative research allows for changes to be made to the methods used during the research process. This process was applied during the phase of focus group interviews. When foods presented to one group did not meet the participants' approval, the suggestions made were applied to the preparation of the food for the next group and the revised recipe evaluated. For example, the first group judged the pumpkin as 'too watery' and not sweet. For the second group, pumpkin was fried in margarine without the addition of water and half a cup of sugar added as suggested. The second group judged the pumpkin to be correctly prepared.

3.3.3 Data analysis

3.3.3.1 Analysis of demographic data

Descriptive statistical analyses of the demographic data, i.e. age, household size, time lived in the area, language spoken and the environmental data were done by the Epi Info version 6.0 (Dean *et al.*, 1994) statistical program.

3.3.3.2 Analysis of qualitative interview data

The first step in the analysis of the interview data was to study each completed interview schedule, identify foods, recipes and amounts described and to summarise these onto separate recipe sheets (Appendix D). Narratives about portion sizes and serving sizes were summarised for each participant.

In the second stage, the English transcripts of the tape recordings were studied and coded in the same way as the interview schedule. The two sets of data were then compared. The data obtained by both methods was in agreement for all participants.

Observational data were categorised and summarised.

3.3.3.3 Quantitative analysis and the development of recipes

Once recipes had been summarised on the recipe forms, foods were coded according to the codes used in the NRPNI Food Composition Tables (Langenhoven *et al.*, 1991a)

Recipes were classified according to their main ingredients and preparation methods. Each type of recipe was given a code. For example, all recipes which described pumpkin fried in margarine with sugar added were coded as A010. A computer programme was written using Foxpro 2.6a software (Microsoft, 1993) to calculate the number of recipes in each category, the ingredients used in each category of recipe and the average amount of ingredients for each recipe. From this, the most common recipes were identified and the amounts of ingredients were converted to practical measurements. Where participants had indicated amounts as purchased (AP) for foods with wastage (such as potatoes, carrots and pumpkin), edible portion (EP) weights were calculated. All amounts in the final recipes were given as EP. These recipes were then tested and prepared for presentation to focus groups.

With regard to single food items, such as fruit, bread, vetkoek, dumplings and drinks, the type, frequency of use and, when applicable the portion sizes were analysed as frequency distributions. The means, standard deviations, ranges, medians and modes of all portion sizes were calculated.

3.3.3.4 Analysis of focus group data

The tape recordings of the focus group discussions were first translated by the Tswana speaking research assistant and transcribed by the researcher. In addition the tape recordings were translated and transcribed by an independent translator. The two sets of transcripts were compared for any disagreements before being further analysed.

The comments on each recipe were categorised and examined. Where necessary, alterations to the recipes were made. The responses to the questions regarding the serving of food and food habits were coded, computerised and analysed using the Epi Info (6.0) statistical program (Dean *et al.*, 1994).

The mean, standard deviation and ranges of portion sizes of served foods were calculated and compared to the results obtained from the individual interviews.

3.4 RESULTS

3.4.1 Sample description

3.4.1.1 Number, age and household size per area

The sample comprised 32 participants. The number of participants from each area and their mean ages and family sizes are given in Table 3.1.

Table 3.1: Number, mean ($\pm$ SD) age and household size of participants from each stratum (N=32)

Area	N	% Sample	Age (years)		Number in household	
			Mean	¶SD	Mean	¶SD
Moshawane	7	22	35,6	17,1	7,2	3,5
Farms	9	28	34,1	9,5	6,4	2,8
Informal settlements*	7	22	35,6	13,1	5,1	1,7
Ikageng*	4	13	38,8	13,9	6,8	2,1
Mmabatho	5	15	45,6	4,3	6,0	2,3
Total	32	100	38,0	13,4	6,3	2,7

¶SD: standard deviation; * Six participants were recruited by the contact person in Ikageng. However, two of these lived in the informal settlements adjacent to Ikageng. The data of these two participants were analysed together with that of the five participants recruited from Top City.

The ages of the women participants varied from 19 to 72 years, with 63% of the sample being in the age group between 20 and 40 years. There were no significant differences between the mean ages of the participants from the farms, Moshawane, Ikageng and the informal settlements ($P>0,05$). However, the mean age of the participants from Mmabatho (45,6, SD= 4,3 years) was significantly older than that of the other areas (34,1, SD= 9,5 to 38,8, SD=13,9 years) ($P<0,001$).

Mean household size was the smallest in the informal settlements (5,1 SD=1,7 persons) and the largest in Moshawane (7,2 SD=3,5 persons). However, there were no significant differences between the mean household sizes of the participants from the different areas ($P>0,05$).

3.4.1.2 Home language

The home language spoken by 78% (25) of the participants was Tswana. Of these, four participants had either one or both parents who were not Tswana speakers (two Xhosa and two North Sotho). The home language of four of the non-Tswana speakers was North Sotho, that of two was Xhosa and one was Pedi. The non-Tswana speakers lived on the Fochville farm (3), in Mmabatho (3) and in Top City (1).

3.4.1.3 Acculturation

The majority of the participants (59%) had been living either in the same place or within the same area for 10 years or longer (Table 3.2).

Table 3.2: Length of time participants had lived in the area (N=32)

Area	Since birth	Since childhood	> 10 years	6 - 10 years	1-5 years	< 1 year
Moshawane	2	2	2	0	1	0
Farms	2	3	1	0	2	1
Informal settlements	0	0	0	1	4	1
Ikageng	1	2	0	2	0	0
Mmabatho	0	0	4	1	0	0
TOTAL % Sample	5 15,6	7 21,8	7 21,8	4 12,5	7 21,8	2 6,3

Three of the participants on the farms were fairly recent arrivals, having lived there for less than five years. One of the recent arrivals was on the Barberspan farm and had previously lived in Delareyville, a town approximately 30 km away (Figure 3.1). The other two recent arrivals were at the Fochville farm, one of whom had come from another farm in the area and the other from Viljoenskroon, a nearby town. Of note is the fact that four of the seven had been living in the area of the farm since childhood.

Of the seven participants in the informal settlements, five (71%) had lived there for less than five years. One of these had previously lived in Ikageng, two in villages in the Potchefstroom and

Lichtenberg districts, one in Taung in the Phokwane district and one in Bethlehem in the Free State.

All the participants in Ikageng and Mmabatho had lived there for more than five years. All, except one, of the Moshawane participants had lived there for longer than 10 years. Similarly to the farms, four had lived in Moshawane since childhood. In order to establish the extent of acculturation, the urban participants were asked if they had relatives' still living in a rural area and, if so, how frequently they visited them. Of the 16 urban participants, 13 had relatives in rural areas, 10 of whom visited their families once to four times a year.

3.4.1.4 Occupation

The majority (22 or 69%) of the participants were housewives. The occupations of the participants differed markedly between Mmabatho and the other areas. In Mmabatho, four of the five participants were employed at the University of North West, two as lecturers and two in administrative positions, while one participant was a housewife. Only five of the other participants were employed. Two of the participants from the farms and one from the informal settlements were domestic workers; one from the informal settlement was a worker at the University of Potchefstroom for CHE; and one of the participants at Moshawane ran a small shop (*spaza*) in the village while another was a teaching assistant at the school.

3.4.2 Environment

3.4.2.1 Food storage and preparation facilities

As could be expected from the description of the environments, food storage and preparation facilities varied with the area. The participants living in Ikageng and Mmabatho had a considerably wider variety of storage and cooking facilities than those from the other areas. The storage facilities available in each area are shown in Table 3.3 and the cooking appliances in Table 3.4.

Table 3.3: Food storage facilities available in each area (N=32)

Area	Refrigerator N	Freezer N	Cupboards N	Aluminium bin N
Moshawane	0	1*	4	3
Farms	1	0	8	3
Informal settlements	1*	1*	7	1
Ikageng	3	2	4	1
Mmabatho	5	4	4	0
Total	10	8	27	8
% Sample	31	25	84	25

* Paraffin operated

Refrigerators were present in a third (10) of the homes visited, eight of which were in Ikageng and Mmabatho. One home in the informal settlement had a paraffin (kerosene) operated refrigerator while one of the farm homes had a refrigerator. Separate freezers were owned by four of the Mmabatho participants, two Ikageng participants and one participant each from Moshawane and the informal settlements. Closed cupboards and/ or aluminium bins were used for storing dry supplies.

Table 3.4: Cooking facilities available in each area (N=32)

Area	Stove N	Oven N	Hot plate N	Open fire N	#Mbola N	Other N
Moshawane	1	0	3	7	0	0
Farms	2	1	5	2	1	0
Ikageng	4	3	1	1	0	2*
Informal settlements	4	1	2	1	2	0
Mmabatho	5	5	1	1	0	10**
Total	16	10	12	12	3	12
% Sample	50	31	38	38	9	38

*Electric frying pan and griller;

** Microwave ovens: 4

Grillers: 3

Deep fat fryer: 1

Electric frying pans: 2

A *mbola* is large aluminium can in which a fire is made. Holes are made in the sides of the can for ventilation. In winter they are taken into the house for heating.

All the Mmabatho participants and one Ikageng participant had both an electric stove and oven. One participant at Mmabatho and one on a farm had a coal stove and an oven. Therefore, as will be seen from the descriptions of food preparation methods, baking, roasting and other dry heat cooking methods were seldom used. In most cases paraffin was used as the fuel for the hot plates (*primus*). In Moshawane, although some participants had both inside and outside cooking facilities, the preferred cooking method was to use the three-legged pot on an open fire in the *lapa*. Food was cooked inside only in rainy, very cold or very hot weather.

In Mmabatho, a wide variety of cooking methods was used as is evident from the variety of cooking appliances (Table 3.4). However, two households avoided frying for health reasons.

3.4.2.2 Food sources

Questions regarding the purchase and acquisition of food were asked to ascertain the extent to which participants were dependent on their own resources for food and whether they received food supplies from other people such as employers or relatives. The numbers of participants who produced some of their own food are shown in Table 3.5 and the food procurement patterns, including the collection of wild fruit and vegetables from the veld, in Table 3.6.

Table 3.5: Own food production in the different areas (N=32)

Area	Vegetable garden N	Fruit trees N	Cattle N	Chickens N
Moshawane	2	0	6	4
Farms	1	0	2	5
Informal settlements	3	4	0	1
Ikageng	0	3	0	1
Mmabatho	4	4	0	0
Total	10	11	8	11
% Sample	31	34	25	34

It is noteworthy that only one third (10) of the participants grew their own vegetables and that four of these were in Mmabatho and three in the informal settlements. The one vegetable garden

on a farm (at Fochville) had just been planted with beetroot and carrots. The other gardens were producing spinach, carrots and onions.

Although none of the participants on the farms had their own fruit trees, they were allowed to pick fruit from trees on the farms in season. The most commonly grown fruit trees in Ikageng, the informal settlements and Mmabatho were peach trees, with apricot and fig trees also mentioned. One of the Mmabatho participants also had grape vines. Wild berries (*morethwa*) were picked from the veld by a few participants in Moshawane and Ikageng when available, but this was not a frequent source of food.

Varying numbers of cattle were owned by the participants of Moshawane. However, few of them used the milk for their families, selling it instead.

Although 10 households kept chickens, few ate the eggs. The main purpose for keeping chickens seemed to be for the sale of the eggs and for breeding chickens for sale. None of the participants mentioned insects as a source of food.

Table 3.6: Food procurement practices in the different areas (N=32)

Area	Local stores N	Town stores N	Employer N	Relatives N	Church N	Veld N
Moshawane	5	7	2	6	0	2
Farms	4	9	9	5	0	1
Ikageng	4	4	2	0	0	1
Informal settlements	7	7	1	4	1	1
Mmabatho	5	5	0	0	0	0
Total	25	32	14	15	1	5
% Sample	78	100	44	47	3	16

‘Local store’ in the case of the farms, refers to, first, a small shop run by the employer on a Barberspan farm and second, to a van with basic supplies that visited the Fochville farm weekly.

In the Moshawane and the urban areas, 'local stores' refer to *spazas* from which perishables such as milk, bread, meat and chicken are bought as needed.

All participants purchased the bulk of their food needs, usually monthly, from stores or supermarkets in nearby towns. The participants living in Ikageng and its informal settlements, with easy access to Potchefstroom, tended to shop there more frequently.

Mmabatho participants shopped at the three major supermarket chains, OK, Pick 'n Pay or Shoprite Checkers, depending on prices, special offers and convenience. In all areas, most shopping was done at the end of the month.

Workers on two of the farms received a milk ration of one litre per day. Two of the participants, who worked as domestics, were given food to take home by their employers. On the other farm, workers received a bag of vegetables, including cabbage, pumpkin, potatoes and onions in the middle of each month. Two of the participants in Moshawane had received maize as payment for work done on farms during the harvest seasons. The participants who received food from their employers in Ikageng and Top City were domestic workers who sometimes brought some food, depending on what they were given by their employers, home.

3.4.3 Food intake

The purpose of the preliminary study was to describe the types and preparation methods of foods eaten by the African population of the North West province. Therefore, no nutrient analyses of the dietary data have been done and the nutritional adequacy of the diets will not be discussed.

As the meal and food intake patterns of the participants in Mmabatho differed considerably from those of the other areas, these will be dealt with separately under each heading.

3.4.3.1 Meal patterns

(a) Moshawane, Farms, Ikageng and Informal Settlements

Two different meal patterns, specifically with regard to the meals eaten in the mornings, were described by participants in these areas. Most of the participants in Moshawane (five), one participant on a farm and two participants in the informal settlements had the following pattern:

Early morning (05h00-07h00):	Tea or coffee either on its own or with bread (white or brown), usually eaten without a spread, but if available, margarine, peanut butter or jam might have been used.
11h00:	Stiff maize meal porridge (<i>bogobe</i>) with <i>sesebo</i> , i.e. a food which that accompanies the porridge. This was either a vegetable, most frequently cabbage or tomato, and onion sauce or a protein rich-food, commonly canned pilchards or chicken
Evening:	Stiff maize meal porridge and <i>sesebo</i> , as for the midday meal, but sometimes with meat or chicken.

The other participants (two in Moshawane, eight on the farms and five from the informal settlements) ate breakfast, usually consisting of stiff maize meal porridge with milk or *sesebo* at approximately 09h00. Lunch, as described above for the 11h00 meal, was eaten between 13h00 and 14h00. One participant (in the informal settlement) did not eat lunch. The time and content of the evening meal were the same as that already described.

The meal patterns of the participants in Ikageng were similar to the above, except that breakfast included soft porridge or breakfast cereal. Maize meal porridge was sometimes replaced by samp, maize rice or rice. A wider variety of vegetables and salads were eaten both during the week and on weekends.

In all these areas, the meal pattern on Sundays differed from that during the week. Even the poorest families try to make the midday meal 'special' in some way. When available, rice

replaced the stiff maize meal porridge. Pumpkin or carrots were served instead of, or in addition to cabbage, and beetroot salad was almost obligatory. The protein source was chicken (usually fried) or, when available, beef or mutton. Puddings such as canned peaches (most common) or guavas and custard were popular.

Fruits, when available, were eaten as snacks between meals. Fat cakes (vetkoek, *mašušū*) which are balls of bread dough fried in deep fat, were also popular as snacks or instead of bread in the early morning.

(b) Mmabatho

In Mmabatho, the meal pattern varied between households and even within households, depending on circumstances. Typically the meal pattern was 'western' and can be summarised as follows:

Breakfast: Ready-to-eat cereal/ soft maize meal porridge or oats with milk and sugar
Bread, or toast (either in addition to or instead of cereal)
Tea or coffee

Midmorning: Tea or coffee

Midday: If the participant ate lunch at work:
Sandwiches (usually brown bread) with various fillings such as cheese, tuna or egg
Fresh fruit and/or salad
Drink : fruit juice or carbonated beverage
If the participant went home for lunch:
Meat, fish or chicken or other protein rich food
Starch such as rice, pasta or potatoes
Cooked vegetable or salad
Fruit juice, tea or coffee

Afternoon: Tea, coffee or fruit juice or carbonated beverage

Evening: Meat, fish or chicken

Starch such as rice, pasta or potatoes (only two participants ate stiff maize meal porridge daily)

One or two vegetables and/or salad

Tea or coffee

During the week the evening meal was the main meal of the day. Over the weekend, the meal pattern varied depending on the families' activities, but generally the midday meal was the main meal on Sundays.

3.4.3.2 Bread and cereals

Table 3.7. shows the bread and cereal intakes of participants in all areas.

Table 3.7: Cereal and bread used by the sample in all areas (Other N=27, Mmabatho N=5).

Cereal/ Bread	¶Other N	Mmabatho N	Total N	% Sample
Maize meal porridge (stiff)	27	2* 2**	31	97
Maize meal porridge (soft)	25	1	26	81
Maize rice	4	0	4	12,5
Samp (only)	4	0	4	12,5
Samp and beans	9	5	14	44
Samp and peanuts	3	1	4	12,5
Sorghum (mabella)	9	1	10	28
Oats porridge	3	1	4	12,5
Bread, white	9	3	12	37,5
Bread, brown	13	5	18	56
Fat cakes	18	2	20	62,5
Dumpling	11	1	12	37,5
Rice	15	5	20	62,5
Sweet cakes/biscuits	1# 8##	3# 2##	14	44

¶ Other=Moshawane, informal settlements and Ikageng

* Daily; ** 2-4 Times per week; # Once a week; ## On special occasions only

(a) Moshawane, Farms, Ikageng and Informal Settlements

The staple cereal of all these participants was maize, eaten as stiff porridge (*bogobe*) (firm enough to be taken in pieces and eaten by hand), but also as soft porridge (*papa*, eaten with a spoon), sour porridge, maize rice or samp. Sorghum (*mabella*) was sometimes mixed with maize meal or used on its own to make stiff or soft porridge by several participants. Fine mabella was used for making soft or sour porridge (*ting*) while coarse mabella was used for stiff mabella porridge. Oats porridge was only mentioned by three participants.

Refined maize meal was used by all the participants interviewed except one, who used unrefined maize meal (*hamermeul*). However, on the farms and in Moshawane, the participants ground maize themselves to make samp. Samp was eaten either on its own with oil, Holsum or margarine added (*dikgobe*) or mixed with dried beans or peanuts (*kubu*). Rice was eaten instead of stiff maize meal porridge at the midday meal on Sundays.

Brown or white bread was eaten mainly in the early morning, but, in the urban areas, also during the day as a snack, typically with atchar and polony.

Fat cakes were popular and used as substitutes for bread or as snacks. Fat cakes were eaten either hot or cold. Dumpling, a steamed yeast dough mixture, was sometimes eaten with stews instead of stiff maize meal porridge.

(b) Mmabatho

Starches typical of the other areas were used less frequently. For example, stiff maize meal porridge was eaten daily by only two participants. Samp and beans were used regularly (2 to 4 times a week) by two participants and once a week, or less, by the remainder. The participants made more use of potatoes, rice and pastas than of maize meal porridge.

Dumplings were made and eaten regularly by only one subject (for the Sunday evening meal). Fat cakes were not as popular as in the other areas.

Cakes and biscuits were eaten once a week (usually over the weekends) by three households, while two participants said that these were luxuries to be used only on special occasions.

3.4.3.3 Vegetables

There was a marked contrast in the consumption pattern of vegetables between the participants in Mmabatho and in the other areas, as can be seen from Table 3.8.

Table 3.8: Vegetables used by the sample (Other N=27, Mmabatho N=5).

Vegetable	†Other N	Mmabatho N	Total N	% Sample
Cabbage, cooked until brown*	25	5	25	78
cooked for short time	2		7	22
Tomato and onion sauce	14	3	17	53
Pumpkin	19	5	24	75
Spinach/ <i>Thepe</i>	12	4	16	50
Potato**	10	5	15	47
Carrots	6	1	7	22
Green beans	1	4***	5	16
Beetroot salad	27	5	32	100
Potato salad	2	2	4	12,5
Cauliflower ***	0	1	1	3
Green peas ***	0	3	3	9
Mixed vegetables ***	0	3	3	9
Mushrooms	0	2	2	6

† Other= Moshawane, farms, informal settlements and Ikageng

* Cooked until brown refers to cooking methods where the cabbage was cooked for a long time, so that the final product appeared brown, in contrast to cooking for a short time so that the cabbage was crisp and green at the end of the cooking period.

** All forms of potato, i.e. boiled, baked, roasted, mashed and french fries were eaten in Mmabatho, while only mashed potatoes and french fries were eaten in the other areas.

*** Frozen

(a) Moshawane, Farms, Ikageng and Informal Settlements

Vegetables were used as an accompaniment (*sesebo*) for the stiff maize meal porridge. Small portions of a limited variety of vegetables were used by the participants in these areas.

All the participants used cabbage (*kabeshe*) cooked in a variety of ways. The most popular method of preparation was to boil the cabbage, drain it, add potatoes, onions and/or tomatoes, boil again, drain if necessary, add oil or Holsum and then to fry until the mixture was brown. Only two of the participants specifically said that they stopped cooking the cabbage while it was still green.

A cooked tomato and onion sauce, called tomato and onion 'gravy' by the participants, was used by 14 (50%) of the participants as *sesebo*. Preparation methods were similar, the only differences being in the proportions of tomato and onion used and the addition of curry or other spices.

Pumpkin (*lephutse*) was popular, used by 19 (70%) of the participants. Pumpkin was usually eaten at the Sunday meal. Although each subject had her own way of preparing pumpkin, all added margarine, oil or vegetable fat and sugar.

Spinach was sometimes used instead of cabbage by 12 (44%) of the participants. *Thepe* (wild spinach) was picked only by a few participants and then only when available in the veld. Spinach and *thepe* were cooked with the addition of potatoes, tomatoes, onions and fat.

Potatoes were generally cooked with another vegetable such as cabbage, spinach or carrots. When eaten on their own, they were mashed with oil, margarine or Holsum. French fries were made by seven participants (25%).

Beetroot salad (cooked, grated beetroot with onion and vinegar) was very popular and was eaten by almost all the participants at the Sunday meal. Other salads mentioned were cabbage salad, and cabbage and carrot salad. Lettuce and cucumbers were only mentioned by one participant in Ikageng.

Other vegetables mentioned, but not used by many participants, were carrots and green beans.

(b) Mmabatho

As can be seen from Table 3.8 above, a wider variety of vegetables were used in Mmabatho than in the other areas. Frozen vegetables, especially green beans, green peas and mixed vegetables were popular, both as ingredients in stews and on their own.

Salad vegetables such as tomatoes, lettuce and cucumber were more common, with all participants serving at least one salad per day.

Another difference in the vegetable consumption pattern of Mmabatho compared to the other areas was the serving of two vegetables, rather than only one, at main meals.

3.4.3.4 Fruit

Fruit was popular, but its use was limited by its cost and unavailability. As with vegetables, the consumption patterns of fruit were similar in Moshawane, on the farms, in the informal settlements and in Ikageng (Table 3.9)

Table 3.9: Fruit used by the sample (Other N=27, Mmabatho N=5).

Fruit	Other N	Mmabatho N	Total N	% Sample
Oranges	25	4	29	91
Apples	21	3	24	75
Bananas	21	3	24	75
Peaches	6	2	8	25
Pomegranates	2	0	2	6
Figs	1	1	2	6
Grapes	2	4	6	18
Pears	0	2	2	6
Pawpaws	0	2	2	6

Fruit	¶Other	Mmabatho	Total N	% Sample
	N	N		
Apricots	0	2	2	6
Watermelons	2	1	3	9
Canned fruit	15	4	19	59

¶ Other= Moshawane, farms, informal settlements and Ikageng

(a) Moshawane, Farms, Ikageng and Informal Settlements

The most popular types of fruit in all areas were oranges, apples and bananas, eaten by 75% to 91% of the sample. Consumption of other fruits such as peaches and apricots depended on the season and these were eaten mainly by those participants with fruit trees. On the farms and in Moshawane, fruit was bought at the end of the month and, once finished, no fruit was available until the next month. In the urban areas, fruit was bought more frequently, usually in mixed packs. Canned fruit, most often peaches served with custard, were popular as a dessert on Sundays.

(b) Mmabatho

Fruit was consumed more frequently in Mmabatho than in the other areas, with all the participants having at least one portion of fruit per day. Of the five participants, four had their own fruit trees, so had access to a wide variety of fruits in season.

3.4.3.5 Meat, chicken, fish and eggs

The pattern of consumption of protein-rich animal foods is shown in Table 3.10.

Table 3.10: Frequency of use of animal protein-rich foods by the sample (Other N=27, Mmabatho N=5).

Protein-rich food	¶Other	Mmabatho	Total N	% Sample
	N	N		
Beef - stewed	10	5	15	47
Beef - fried	13	5	15	47

Protein-rich food	¶Other N	Mmabatho N	Total N	% Sample
Mutton - stewed/ fried	2	1	3	9
Pork - stewed	2	0	0	6
Chicken - stewed	4	5	9	14
Chicken - fried	16	5	21	66
Chicken feet	7	0	0	22
Chicken bones	7	0	0	22
Canned pilchards	15	4	19	59
Fried fish	4	4	8	25
Canned tuna	0	2	2	6

¶ Other = Moshawane, farms, informal settlements and Ikageng

(a) Moshawane, Farms, Ikageng and Informal Settlements

The cost of protein-rich foods, especially red meat, seemed to be prohibitive of their use. Chicken was used more frequently than red meat (44% of the animal protein-rich consumption was chicken compared with 35% red meat). Chicken feet were used to make stews as *sesebo* or fried and eaten as a snack. In the informal settlements, the participants bought 'chicken bones', 250 g packets of chicken bones with a very small amount of meat attached. This they made into stews, mixed with samp and beans or fried.

Beef was the most commonly used red meat (85%) and was either stewed or fried. Minced meat was only mentioned by a few of the participants. Offal (*mogodu*) was also eaten when available. Mutton and pork were used occasionally by two participants. *Boerewors* (sausage) was popular in the urban areas. French polony or garlic polony was eaten with atchar on bread as a sandwich in the urban areas. French polony could be bought by the slice from a *spaza*.

Although participants in the urban areas mentioned fried fish, most of the participants used canned pilchards, either in tomato or chilli sauce. Canned pilchards were the primary source of protein in the rural and farm areas. Most of the participants (14) removed the bones from the pilchards before mixing them with onions or tomatoes.

Eggs were used by 17 (63%) participants. These were either fried or scrambled and usually eaten with stiff maize meal porridge at the midday meal. Scrambled eggs were sometimes mixed with pilchards or tomato and onion sauce.

(b) Mmabatho

Although both chicken and red meat were used by all the participants in Mmabatho, chicken was eaten more frequently (twice to four times per week). Preparation methods of chicken were more varied than in the other areas and included roasting and grilling, in addition to frying and stewing. Beef was served once a week by three of the five participants and twice to four times a week by two participants. Beef included minced meat, sausages and boerewors. Preparation methods of beef were roasting, frying, grilling and stewing. Mutton was mentioned by only one subject, while pork was not mentioned.

Although canned pilchards were used by four of the participants, these were not used as frequently as in the other areas, being used twice to four times or less per week. Canned tuna was used by two of the participants as a sandwich filling or a salad. Fried fish, such as frozen hake fillets or frozen crumbed hake was used by four of the participants.

Eggs, boiled, fried or scrambled, were used by four of the participants, either as a light meal or on sandwiches.

3.4.3.6 Beverages

The types of beverages consumed were similar in all areas, thus the results are presented together. Hot beverages consumed were tea and coffee, with tea being the most popular, in all areas. Milk was taken in tea and coffee, although four participants did drink fresh or sour milk as such. Full cream milk was used by all participants except two in Mmabatho who used fat free or 2% fat milk. Yoghurt was eaten by two participants in Mmabatho.

Coffee whiteners (Cremora or Ellis Brown) were used by nine participants. Condensed milk was used by two participants.

Sweeto and Six-O (artificial cold drink concentrates) were used frequently by most families on the farms, in rural areas, Ikageng and the informal settlement. Carbonated beverages were drunk when available on the farms and in Moshawane. Fruit juices and carbonated beverages were much more common in Mmabatho, than in the other areas.

Mageu and motogho, fermented drinks made from maize meal or maize rice, were popular on the farms and in Moshawane. Only two participants mentioned commercial beer and a few said they made home brew.

In Mmabatho, two participants drank wine occasionally while one subject drank a glass of sherry daily. No hard liquor was mentioned by any of the participants.

3.4.3.7 Fats

Fats used for cooking were hard vegetable fat (Holsum) (particularly on the farms and Moshawane), hard yellow margarine and sunflower oil. On the Fochville farm, participants used dripping made from beef intestines for cooking.

In the urban areas, margarine (hard or soft) was sometimes spread on bread.

Cream was not used by any of the participants. Ice cream was bought by households in Mmabatho and Ikageng, especially during the summer and served as pudding on Sundays.

Raw peanuts were popular on the farms and in Moshawane. However, it was difficult to assess the amounts eaten, as participants usually pick and eat them as they walk. As mentioned under cereals, peanuts, whole or ground, could be mixed with samp and served as an alternate to samp and beans.

3.4.4 Focus groups

3.4.4.1 Number and composition of groups

Focus group discussions were held in Moshawane, Barberspan, Ikageng, Top City and Fochville six to seven weeks after the initial interviews. The groups met in the home of one of the participants, except on the Fochville farm, where an unoccupied house was used.

The number of participants in each group compared to the number of participants interviewed in the area are shown in Table 3.11.

Table 3.11: Size and composition of focus groups

Area	Number participants		Comment
	Interviewed	Focus group	
Moshawane	7	7	
Barberspan	5	6	One interviewee could not attend, but was replaced by her mother A woman who was not originally interviewed joined the group
Ikageng	6*	5	One subject was unable to attend
Top City	5	5	One interviewee could not attend, but was replaced by her mother
Fochville	4	5	A woman who was not originally interviewed joined the group

*Includes the 2 participants recruited by the Ikageng contact but who lived in the informal settlements.

3.4.4.2 Results of discussions on foods

The main purpose of the focus group discussions was to check the accuracy of the researcher's interpretation of the recipe and food preparation data collected in the interviews, by presenting the groups with dishes made from the average recipes. The comments and the conclusions of the groups are described below.

(a) Stiff maize meal porridge

Stiff maize meal porridge was presented to all the groups. Porridge made by the researcher was presented to the first two groups (Moshawane and Barberspan). Both groups said that this porridge was not cooked enough and was more like the consistency of 'soft' porridge than that of stiff maize meal porridge. Stiff maize meal porridge made by the research assistant (400 g maize meal: 1 l water, no salt added) was presented to the other three groups. The Ikageng and Fochville group found this to be satisfactory, although both groups wanted salt to be added. The Top City group said the consistency was too soft for stiff maize meal porridge and that more salt was needed.

The groups were asked to describe the proportions of water and maize meal used for stiff and soft porridge. However, they were unable to do this, the responses being 'It depends on the size of the pot' or 'I use as much as is needed to make the porridge thick enough'.

(b) Samp and bean or peanut dish

The samp and bean dish was presented to all groups. The comments from all the groups were that the mixture appeared too 'separate', it was not cooked enough and there was too little salt. However, the proportion of samp to beans was correct.

The samp and beans had been cooked separately, then mixed, making the samp and beans clearly distinguishable in the final product. However, this is not how the participants prepare samp and beans. The method agreed on by all the groups was that the samp is soaked, the beans added and then cooked together for a very long time (the whole morning, four to five hours) until both the samp and beans are very soft, the samp has taken on a brownish colour, and the samp and beans are not clearly distinguishable. Fat, as Holsum, oil or margarine may be added.

The Moshawane group made the same comments regarding the samp and peanut dish. The peanuts may be added either whole to the samp, or they may be ground to a powder, then added the samp once it is soft. The proportion of peanuts to samp (1:1) was correct.

(c) Fat cakes and dumpling

The fat cakes and the dumpling, both made from white bread dough, were satisfactory, although the dumpling had not risen enough. The most acceptable size of a fat cake was 60 to 80 g.

Fat cakes and dumplings were eaten either hot or cold. The Ikageng group preferred to eat fat cakes hot, as soon as they were made, while the other groups usually ate them cold. The Fochville group said that fat cakes tasted better the day after they were made. The Moshawane group liked cooking dumplings on top of a meat stew and eating it hot.

All the participants used instant yeast for making fat cakes and dumplings and fried fat cakes in deep oil. A comment about the use of baking powder was that it was 'useless'.

(d) Beef stew

The Fochville group judged the beef stew as good, but the Ikageng group found it too bland, needing more salt and spices. It was agreed that the vegetables in the stew (potatoes, onion and tomatoes) were those that the members of the groups usually added, depending on availability. One member of the Ikageng group did not like putting tomatoes in stews. Other vegetables such as canned peas or mixed vegetables could be added if available.

(e) Chicken, chicken feet and chicken bone stew

The chicken stew was judged as tasting and looking good by the Moshawane and Barberspan groups. However, as with the beef stew, the groups felt that more salt was needed. Potatoes, onions and tomatoes are the vegetables usually added to the stews.

A stew made from chicken feet was presented to the Top City group, and this also appeared and tasted as they liked it. Although the skin of the chicken feet is usually removed, the participants in Top City leave it because, as they said, 'There is nothing left if the skin is removed.'

Chicken bone stew was prepared from the bones of a de-boned chicken. The group's reaction

to this stew was that it was very delicious, as it had much more meat than that which they prepare from the bones bought from the *spazas*. These are literally just bones. The only meat is the slivers still attached to the bones.

(f) Vegetables

The comments about all the vegetables, except the pumpkin, were that they appeared and tasted good (*monate*), but there was too little salt. The groups also suggested that the spinach needed more fat and pepper.

As for the pumpkin, the comment of the first groups (Moshawane and Barberspan) was that it was too watery. The pumpkin had first been boiled in a little water and then the margarine and sugar added. The participants do not cook pumpkin in water first. They add the fat (vegetable fat, oil or margarine) and sugar to the raw pumpkin so that the pumpkin is fried in the fat. The end product is therefore very rich and sweet. The proportions used were 400 g pumpkin, 50 g margarine and 100 g sugar. When pumpkin was prepared in this way and presented to the Ikageng and Top City groups it was judged as *monate* (good).

3.4.4.3 Results of discussions on questions on the storage and serving of food

(a) Keeping of food from meal to meal

Only one of the groups, Fochville, said that they kept food regularly from meal to meal. They cooked enough food for breakfast and kept it for the midday meal. The other participants only cooked enough food for one meal at a time. The Top City and Moshawane groups did keep food left over at one meal for the next meal, but only in winter. The Moshawane group reheated the food before serving it, while the Top City group ate stored food cold.

(b) Storage of milk

As most of the participants did not have refrigerators, keeping milk fresh was a problem and only small amounts (500 ml) were bought at a time. In Moshawane, milk was boiled to prevent it from

going sour, while in Top City and Barberspan, the milk bottle was placed in a dish of cold water to keep it cool.

(c) Serving of food

In all the areas, the mother served the food for the family onto individual plates. The preferred method of eating was using a dessert spoon or hands, depending on the type of food.

(d) Combinations of vegetables and starch at meals

The participants in all groups, except the Ikageng group, agreed that only one vegetable and starch were served at a meal. On Sundays however, if available, more than one vegetable as well as beetroot salad was served. If rice or samp and beans were served at a meal, stiff maize meal porridge was not also served. Dumpling was served instead of stiff maize meal porridge, or other starch, in all the groups, except in Moshawane where dumpling would also be served together with rice.

The Ikageng group liked serving two vegetables with contrasting flavours at a meal, for example cabbage and pumpkin.

(e) Sweets and chocolates

The participants in all groups bought both sweets and chocolates when money was available. Within the groups, some preferred sweets and others chocolates.

(f) Cooking methods similar to mother

All the groups said that they cooked like their mothers, especially dishes such as porridge, cabbage and dumplings. However, the validity of using this to measure acculturation is questionable, as there was no indication of the extent of acculturation of the mother.

3.4.4.4 Portion sizes

Participants were asked to dish out the foods they would serve to their husband, themselves and a child. The groups then discussed these portions and the portions were adjusted until they reached a consensus. The portions for the male, female and child were combined for analysis. Although the number of portions weighed as given in Table 3.12 appear small, the portion sizes had been reached by agreement by all the participants in the focus groups.

Table 3.12: Mean ($\pm$ SD*) of portion sizes agreed upon by the focus groups

Food	N**	Mean (g)	SD* (g)	Minimum (g)	Maximum (g)
Stiff maize meal porridge	5	302	64,6	220	370
Rice	9	117,7	28,1	80	80
Beef (stew with bone, without vegetables)	5	105,0	48,7	40	170
Chicken stew, without vegetables	4	48,8	28,4	30	90
Pilchards with onion	2	60	14,1	50	70
Cabbage	13	58,5	26,7	25	120
Pumpkin	9	45,6	23,8	25	100
Tomato and onion sauce	13	40,8	18,5	20	95
Carrots and potato	3	71,7	16,1	60	90
Beetroot salad	9	36,1	18,0	20	80
Dumpling	5	65,0	12,2	55	80
Bread	6	68,3	18,9	55	90
Jam	3	20,0	10,0	10	30

* Standard deviation; ** Number of samples weighed

3.5 DISCUSSION

This discussion will consider two aspects: first, the need for the development of a culture-sensitive QFFQ and the reasons for selecting the specific methodology used and second, the results of the preliminary study and their application to the development of the QFFQ.

3.5.1 Culture in relation to the development of dietary assessment instruments

Food intakes do not take place in a vacuum, but form part of the complex social and cultural behaviour of individuals, groups and societies (De Garine, 1972; Peltó, 1981; Ritenbaugh, 1981; Stewart & Tinsley, 1995). Food habits, and thus nutrient intakes, are linked to virtually every part of a society's culture system. This includes food procurement, production, processing, distribution, consumption, storage and disposal practices, attitudes and beliefs towards food, and the role of food in the socialisation of the individual (De Garine, 1972; Kuhnlein, 1989; Terry, 1994). The assessment of dietary intakes must therefore consider the culture of the study population (Jerome, 1997). Consequently dietary intake measurement instruments used for one cultural group may yield inaccurate results if applied to another group (Benavente & Pobocik, 1997; Teufel, 1997). Such instruments may, at best, be misunderstood by the study population and at worst, cause offense and be met with mistrust and resistance (Teufel, 1997).

The need for dietary assessment methods that take the culture of the target population into account was highlighted at the First International Conference on Dietary Assessment Methods in 1992 (Buzzard & Sievert, 1994; Cassidy, 1994; Hankin & Wilkens, 1994; Kohlmeier, 1994). The term 'culture sensitive' was coined to describe dietary assessment methods that take the values and behaviours of a specific cultural group into account (Cassidy, 1994). The need for the development of culturally sensitive dietary assessment methodologies was reiterated at the Second International Conference on Dietary Assessment Methods in 1995 (Coates & Monteilh, 1997; Jerome, 1997; Kigutha, 1997; Romieu *et al.*, 1997; Teufel, 1997). Regarding food frequency questionnaires, Teufel (1997) has identified four levels of cultural consciousness:

- (a) Cultural awareness - the recognition of culturally unique behaviours. This would apply to the development of a food frequency questionnaire by providing blank spaces to record culture specific foods not covered by the questionnaire.
- (b) Cultural sensitivity - the questionnaire provides for culturally unique behaviours by adding culture specific and traditional foods to the food list.
- (c) Cultural appropriateness - the food frequency questionnaire is inoffensive and useful.

- (d) Cultural competency - this implies both an understanding of the culture of the study population, and the use of this understanding to develop an assessment instrument that takes the cultural beliefs and practices of the population into account. The development of such an instrument requires the direct involvement of informed members of the population from the outset of its construction.

The aim of the present study was to develop a culturally sensitive quantitative food frequency questionnaire (QFFQ). To achieve this, the researcher undertook a preliminary study using a combination of qualitative and quantitative approaches. The aim was to gain knowledge of, and insight into, the culture specific food preparation and intake behaviours of Africans in the North West province.

3.5.2 Methodology

In order to develop a culturally sensitive QFFQ, a sound knowledge of the food habits of the study population must be obtained (Hankin & Wilkens, 1994). The present study used a combination of in-depth, individual interviews and focus group discussions as data collection methods and included both qualitative and quantitative approaches. Below is a discussion of the different approaches to collecting background food habit information before the development of a QFFQ described in the literature.

3.5.2.1 The use of existing knowledge of the population

One approach is to study existing information such as previous dietary surveys and to apply this information to the selection of food items to include in the QFFQ (Hankin & Wilkens, 1994; Tucker *et al.*, 1997). However, this approach is useful only if the studies had been done on the specific population and shortly before the planned study because food habits change with time (Chiva, 1997). In the case of the present study, little information exists regarding the food habits of the African populations of Southern Africa and specifically of the North West Province. Neither in a recent review of the traditional diets of South Africa (Labadarios *et al.*, 1996), nor of the dietary intakes of South Africa (Vorster *et al.*, 1997b) is there any mention of studies of the Tswana, or the population of the North West province.

There are several descriptions of the food habits of the Xhosa and Zulu populations of the Cape and Kwazulu/Natal in the literature (Lubbe *et al.*, 1973; Lubbe & Maree, 1973; Manning *et al.*, 1974; Kirsten, 1977; Richter *et al.*, 1984; Bembridge, 1987; Ndaba & O'Keefe, 1985; Bourne *et al.*, 1993; Bourne *et al.*, 1994). Huss-Ashmore and Curry (1991) have reported on the food habits and nutritional status of rural Swazi women. The Xhosa, Zulu and Swazi ethnic groups however, belong to the wider Nguni 'family'. This is culturally and ethnically somewhat distinct from the Sotho-Tswana 'family' to which most of the people of the North West province belong (Seligman, 1968; Maylam, 1986; Hirschowitz *et al.*, 1995)

The dietary habits of the Pedi were described in detail by Quin (1964), and more recently by Waldmann (1975) and Ladzani *et al.* (1992). Although both the Pedi and the Tswana belong to the Sotho people, and some of their cultural behaviours may be similar, they are sometimes regarded as two distinct cultural groups (Maylam, 1986).

Descriptions of the dietary habits of the African populations in the Northern parts of Southern Africa have been published for the Shona (Gelfand, 1971), the rural Venda (Lubbe, 1971, Crous & Bocharadt, 1986; Vorster *et al.*, 1994) and the urban Venda (Crous & Borchardt, 1984). The Venda and the Shona have historical links but fall outside the Sotho 'family' (Maylam, 1986), although some elements of the Sotho language and culture are common to the Venda (Maylam, 1986). However, findings regarding their eating habits cannot be directly applied to the African population of the North West province.

Franz (1971) described the eating habits of the Tswana in the Pietersburg district of the Northern Province, and Oudkerk (1965) reported on those of school children in the Pretoria area. Food procurement and intake habits of the Tswanas living in the Kalahari were described by Grivetti (1979). Two more recent studies on Tswana populations have been reported by Steenkamp (1987) and Gresse (1991). Neither of these was directly applicable to the present study. The study by Steenkamp (1987) dealt with female agricultural migrant labourers living under unique circumstances in the western part of the province. Gresse (1991) studied diabetic patients, while the present study considered only healthy individuals. In fact the present study looked at a wider cross-section of the population living in a variety of circumstances in the more eastern parts of the province.

Although the literature referred to above provided helpful information in formulating the QFFQ, it was not sufficient to develop a QFFQ sensitive specifically to the culture of the African population of the North West province. It was therefore necessary to undertake a preliminary study specifically to describe the food intake patterns of this population.

3.5.2.2 Twenty-four hour recalls

A second approach to collecting information before the development of a food frequency questionnaire has been the collection of dietary data by use of the 24-hour recall methodology (Ammerman *et al.*, 1991; Sharma *et al.*, 1996; Campbell *et al.*, 1997; Wang *et al.*, 1997). This data is then used to identify the most commonly consumed food items (Campbell *et al.*) or those which contribute substantially to the energy intake of the population (Sharma *et al.*, 1996; Wang *et al.*, 1997). These foods are then included in the food frequency questionnaire.

The use of the 24-hour recall was not considered suitable for the present study for the following reasons:

- (a) A disadvantage of the 24-hour recall is that it does not give information on the cultural aspects of the diet such as meal patterns and food procurement, preparation, serving and disposal practices. To partially overcome this problem, 24-hour recalls have been combined with food frequency questionnaires, diet histories and observation (Cassidy, 1994; Sharma *et al.*, 1996).
- (b) To obtain meaningful information from 24-hour recalls, a large sample is needed and several 24-hour recalls have to be collected from the same subject. For example, Sharma and co-workers (1996) obtained 24-hour recalls from a total of 135 subjects. This would have been difficult to replicate logistically especially in the rural and farm areas. As has been shown from the description of the study areas, these were very remote, and it took a long time to reach them. Also, more field workers would have been needed. This would have added to the cost and the time of the project as these field workers would have had to be trained.

- (c) The main purpose of 24-hour recalls is to collect data for nutrient analyses, but nutrient analysis was not an aim of this preliminary study (see 3.2.3). The objective was rather for the researcher to become acquainted with the lifestyles, environment and food behaviours of the study population. This could only be achieved by the researcher visiting the homes and personally getting to know the participants using a more open and friendly qualitative approach.

3.5.2.3 Observation and diet records

With participant observation, the researcher or field worker becomes directly involved in the lives of the persons being studied (Skinner & van der Walt, 1997). Participant observation is useful both in the collection of primary data and to verify data already collected by other means such as interviews or questionnaires (Field & Morse, 1992). Participant observation is a means of assessing dietary intakes that does not rely on a respondent's ability to recall their intake (Gittelsohn *et al.*, 1994) and usually involves the keeping of weighed, or estimated dietary records by the field worker. This has been described for the collection of dietary data of young children (Cox *et al.*, 1993; Dop *et al.*, 1994a; Gittelsohn *et al.*, 1994). An example of the use of participation observation in the collection of qualitative dietary data is the work of the anthropologist, Monica Hunter. She lived among the Pondo (an Nguni group in the Eastern Cape) for 11 months in the 1930's and provided useful information on the Pondos' food procurement, preparation and consumption patterns (Hunter, 1979). Participant observation could have been considered as a means of data collection for the present preliminary study. However, participant observation has several drawbacks:

- (a) Participant observation is reactive (Bailey 1987), that is, the presence of the observer is intrusive and may influence the respondents' food intake behaviours (Dop *et al.*, 1994b). A direct effect could be the changing of behaviours either to impress the observer, or to shorten the time required for the observer to be present in the home, or even to create a feeling of sympathy in the observer. The presence of the observer may indirectly affect the food available for the family, especially in poorer households. The respondents may feel obliged to offer food to the observer. This would alter the normal food behaviour pattern and put an additional burden on the food resources of the household. On the other

hand, refusal to take part in a meal might cause offense to the respondent and reduce cooperation. To overcome these problems an explanation of the role and expectations of the observer and very sensitive and unobtrusive handling of the observation would be necessary (Cox *et al.*, 1993; Dop *et al.*, 1994b). Unlike participant observation in other social settings, where the observer may actually enter the setting as a member of the group or community to varying degrees (Field & Morse, 1992) and thus reduce the reactivity of the respondents (Bailey, 1987) this may not be possible in dietary intake studies.

- (b) In view of the above, participant observation requires skilled and trained observers. In addition, to observe the required number of households, several observers would have been needed. This would have been beyond the resources of the present study.
- (c) Participant observation is extremely time-consuming and labour-intensive (Skinner & van der Walt, 1997) and would have unreasonably increased the time required for the preliminary study.

Diet records, either weighed or estimated, are regarded as one of the most accurate methods of collecting dietary intake data (Thompson & Byers, 1994). The keeping of diet records is, time-consuming, places a considerable load on respondents and requires commitment from them (Thompson & Byers, 1994). Also, since respondents must be literate, it would not have been possible to include some of the participants in the sample. Dietary records were therefore not considered to be an appropriate method for the preliminary study. (For further discussion of the use of dietary records in the present study, see Chapter 7).

3.5.2.4 Combination of qualitative and quantitative research approaches

Cassidy (1994) in her article 'Walk a mile in my shoes: culturally sensitive food-habit research' illustrates how qualitative and quantitative approaches can be combined to produce a culturally sensitive dietary assessment instrument. The answers to questions relating to the values and behaviours of a population (who, how, when, where and why?) are best collected by qualitative techniques (Cassidy, 1994; Berg, 1995). As these questions are answered, patterns become

apparent which, when analysed, answer the questions ‘how many?’ and ‘how much?’ leading to the quantitative step (Cassidy, 1994). This principle was applied in the present study. The in-depth interviews were conducted with the participants in their own homes and in their own language using open-ended questions with a semistructured format. The participants talked about who prepared food, how, when and where food was prepared and served. The quantitative questions of ‘how many’ and ‘how much’ were answered by letting the participants demonstrate the amounts of food used to prepare recipes and to actually serve portions of food.

As suggested by Cassidy (1994), the researcher and assistant approached the participants as the learners, while the participants were the experts. In qualitative approaches the researcher is not the most important person in the research process, unlike in the case of quantitative research, where the researcher does something to, or with, the subject (Berg, 1995). The respondent is an equal partner in the research process. The term ‘participant’ or ‘co-researcher’ is used when referring to a respondent in qualitative research rather than the impersonal ‘subject’ used in quantitative research (Olesin, 1994). For this reason, ‘participant’ was used throughout this chapter. The participants in the present study were indeed co-researchers. They willingly shared their food habits and experiences with the researcher, demonstrated how they prepared meals, showed their food storage and preparation facilities and corrected the researcher’s comments. Without the sharing of the knowledge and experiences of the participants, the rest of the project would not have been possible.

3.5.2.5 Focus groups

Focus groups were used in the preliminary study for three reasons:

- (a) A very important consideration in the design of qualitative research studies is the inclusion of measures to ensure the quality, or rigour, of the data (Morse, 1994; Berg, 1995). This is done through triangulation, that is, the use of several kinds of data and/or data collection methods (Janesick, 1994). Thus, focus groups were used, in addition to the in-depth interviews, to confirm the information already collected and to answer questions which arose from the analysis of the interview information. For example, from the interviews it was apparent that while most of the participants prepared certain dishes

similarly, some differed in the way they cooked food and the types and amounts of ingredients used. This gave rise to the question: 'Do you cook like your mother?'

- (b) As pointed out by Cassidy (1994) and Stewart and Tinsley (1994), an advantage of qualitative research is that the participants describe their experiences in their own words. This reduces the chances of the researcher imposing his or her own interpretation on the participants answers. However, the danger still exists, particularly in cross-cultural research, that a researcher may, unknowingly, interpret the information given by the participant according to their own experience or culture (Stanfield, 1994). The focus groups, in the present study, were used to test the accuracy of the researcher's interpretations of the information obtained in the interviews. Janesick (1994) refers to this procedure as a 'member check' or 'audit trail'.

The preparation of the pumpkin dish demonstrates the value of the focus groups as 'member checks'. In the interviews, all the respondents spoke of cooking pumpkin with margarine or vegetable fat and sugar. The researcher interpreted this in terms of her own way of cooking pumpkin, that is, cooking in a small amount of water, draining and adding margarine (25 g) and sugar (15 g). When the pumpkin dish prepared in this way was presented to the first focus group (Moshawane), all the participants exclaimed that it was 'too watery' and 'tasteless'. They then explained how to prepare pumpkin. The pumpkin is fried directly in the margarine (approximately 60 g) and sugar (approximately 100 g) without the addition of water. When the pumpkin was prepared in this way and presented to the next focus group (Barberspan), it was declared to be '*monate*' (delicious). The preparation methods made a considerable difference to the fat and energy content of the dish and could have resulted in lower intakes had the researcher based the dietary analyses on the first instead of the second recipe. Another example was the amount of salt added to the food. Most participants thought that more salt was needed in all the dishes, despite the fact that the researcher had added what she had considered to be more than enough salt.

- (c) The third purpose of the focus groups was to reach consensus on the recipes and serving size. For practical purposes, the recipes included in the QFFQ had to be based on the

average of the amount of ingredients used by the individual participants. The focus groups provided the opportunity for the participants to share their food preparation methods and come to an agreement on how each dish should be prepared.

3.5.2.6 Limitations of the preliminary study

A characteristic of qualitative research described by Janesick (1994) is that the researcher remains in the research setting over time. It might be argued that participant observation over time is the only way to collect quality data on food intakes. However, in reality, this is very difficult to do. In the present study, each area was visited by the researcher only on two occasions. Possibly, different, or more accurate, data could have been collected had the researcher actually lived with the participants for a time or visited the participants more often to observe meal preparation and service, as is done in participant observation (Field & Morse, 1992). Participant observation (as discussed in 3.5.2.3) has its own set of problems and was not practical in the present study. The focus groups were used instead, as described above, as an attempt to compensate for this shortcoming.

Another argument against qualitative research in cross-cultural studies, is that only someone from within the world of the participants can adequately understand and interpret their behaviour (Stanfield, 1994). Also, the presence of the researcher might have influenced the responses of the participants (Field & Morse, 1992). Two measures were taken to attempt to reduce, or prevent, these problems. Firstly, as already described, focus group interviews were used to confirm the researcher's interpretation of the data. Secondly, the research assistant was a Tswana who had grown up in a rural area and who, at the time of the study, lived in an urban area. She could, therefore, relate very closely to the respondents in all the areas. She was the active interviewer while the researcher took the role of a passive observer. In a further attempt to verify the data, an independent Tswana speaking translator translated the tape recordings of both the interviews and focus groups.

A problem with both individual interviews and focus group discussions is that participants may give answers or comments that they think the researcher wants to hear (Judd *et al.*, 1991; Carey, 1994). Several comments by the participants in the focus groups showed that they were not

giving answers to please the researcher. For example, when the first group tasted the stiff porridge cooked by the researcher, one participant exclaimed 'but this is raw!'. Other participants said that the fat cakes were 'burnt' and 'too flat' and the dumpling was not 'risen enough'. Another factor that could have affected the quality of the data obtained from the focus group discussion is conformity (Carey, 1994). Conformity occurs when a participant tailors her contribution to be in line with those of the other group members (Carey, 1994). It was not possible to assess if, and to what extent, conforming took place in the focus groups. All that can be said is that participants expressed a range of opinions on some foods, whereas on others there was immediate agreement by all participants. Also, as one of the purposes of the focus groups was to reach consensus on portion sizes and food preparation methods, some compromising among participants was inevitable.

3.5.3 Extent of acculturation

The aim of the first part of the interview was to determine the extent of acculturation and urbanisation of the participants. A difficulty that arose with interpreting the data relating to the area where participants had previously lived was that only the geographical area was asked, and not whether they had come from a white or African owned farm, village, informal settlement or urban area. This information was necessary to determine the actual amount of time lived in a certain type of area.

The question regarding contact with relatives in other areas (Appendix A) was not comprehensive enough to obtain meaningful information as only the urban participants were asked about contact with relatives in rural or farm areas. The inclusion of questions on whether rural participants visit relatives in urban areas, the average duration of the visits and differences in life style, could have provided more meaningful information on the process of acculturation.

There does not seem to be a clear dividing line between the life styles and food habits of the participants in the different areas. It may be that there is a continuum of life style from the rural to the urban areas. People from one area are in contact with or move to and from the other areas and incorporate aspects from each area into their way of life. Life style, is not only determined by where a person lives, but also by factors such as employment, income, and level of education.

In this technological time, finding an area that has been completely cut off from urban influences would be difficult. For example, in Moshawane, one of the houses had a television set, and so did one of the homes on the farms.

The participants on the farms, in Moshawane and in the informal settlements had a narrower variety of foods in the diet, than those from Ikageng and Mmabatho. The present study cannot determine how much of this difference can be attributed to the life style of the inhabitants of the area, or to other factors, such as availability, income and acculturation.

From this preliminary study, it seemed that it was extremely difficult to get an accurate picture of the extent of acculturation of a population and that many factors need to be taken into consideration, not only the area in which a population lives.

3.5.4 Food storage and preparation facilities

The type of food in the diet is also determined by facilities and apparatus available for food storage, preparation, cooking and serving. Again this appears to be a continuum from very limited facilities in the rural areas and informal settlements, to Ikageng and Mmabatho where there were all the conveniences of modern society. However, even this continuum is not clear, as a participant in Moshawane had a paraffin freezer, a participant on the farms owned a refrigerator and another participant in the informal settlement had a paraffin refrigerator. It appeared from the participants in Moshawane and the farms that, even if other facilities are available, the preferred method of cooking was in a traditional three-legged cast iron pot over an open fire.

3.5.5 Food procurement

From the responses to the questions regarding food procurement, it was evident that, despite the area, all participants relied on stores for the bulk of their food supplies. In Moshawane, the informal settlements and Ikageng, most of the day to day purchasing of supplies was done at *spazas* (see 3.4.1.1). Prices are higher than those in supermarkets, but the convenience may balance the prices, especially when transport costs are taken into account.

In all, only 10 (31%) of the 32 participants had vegetable gardens but none of these could provide sufficiently for the household needs. Wild fruit and vegetables were picked by five (16%) participants when available. This finding is in contrast to that of Steenkamp (1987) who found that 99% of 102 migrant women agricultural labourers in the Kuruman and Augrabies areas made use of wild foods. This difference could be due to variations in the availability between the areas. *Thêpe* (wild spinach) was the most commonly collected wild food both in the present study and the study of Steenkamp (1987). The fact that wild sources of food were used by some of the participants and have been reported by other researchers (Steenkamp, 1987) indicated that these should be included in the QFFQ. The frequent consumption of these foods could make an important contribution to the diet.

Quin (1964) and Steenkamp (1987) reported a similar finding to the present study regarding the keeping of chickens and the use of eggs. Eggs were seen to have greater economic value if kept for hatching than if consumed by the family.

On the farms and in Moshawane, Ikageng and the informal settlements, there appeared to be a fair amount of interchange of food supplies between friends and relatives. For example, one of the workers on the Fochville farm received milk regularly from her sister-in-law's father who milked the cows on the farm. In Moshawane, one participant's parents, who worked on a farm, brought her a weekly supply of eggs, milk and vegetables. The elderly headman in Moshawane received meat, maize meal and vegetables from his son, when he came home at the end of the month. Generally, when relatives came to visit, they brought some gift of food with them. One of the families in Top City received provisions occasionally from their church.

3.5.6 Meal patterns

The typical meal pattern in all areas was three meals a day in contrast to the traditional two meals per day as described by Quin (1964) and Franz (1971). More recent studies of eating patterns of Tswana populations have shown a similar pattern of three meals per day (Steenkamp, 1987; Gresse, 1991).

Several studies over a period of time have described the change in meal patterns to an elaborate

midday meal on Sundays. This seems to be common across most African population groups in both urban and rural areas (Oudkerk, 1965; Manning *et al.*, 1974; Crous & Borchardt, 1984; Steenkamp, 1987; Gresse, 1991). The reasons for the midday meal on Sunday being larger and containing more variety than during the rest of the week can only be speculated upon. One or more of the following could be the reason:

- (a) In many areas the men of the household live and work away from home during the week. Even if they live at home, work hours are long. Therefore, the Sunday meal may be the only occasion that the whole family can eat together and a special effort is made. Also, the men bring supplies such as meat and vegetables from the town.
- (b) Most people do not work on Sundays so there is time to prepare the meal during the morning.
- (c) The custom may have been learnt by domestic workers from their white employers, who traditionally eat a large meal on Sundays.

3.5.7 Food intake patterns

The food intake patterns of the participants from Moshawane, the farms, Ikageng and the informal settlements were very similar to that of insulin dependent (IDDM) and non insulin dependent diabetics (NIDDM) in the Ga-Rankuwa area (Gresse, 1991), and to that of the migrant labourers when living in Augrabies (Steenkamp, 1987).

In the present study, and those of Gresse (1991) and Steenkamp (1987), it was found that maize meal porridge was the staple food of the diet in contrast to the traditional sorghum and millet (Quin, 1964; Franz, 1971). Vegetables were consumed in small amounts as *sesebo*, similarly to the findings of other studies (Oudkerk, 1965; Franz, 1971; Lubbe *et al.*, 1973; Manning *et al.*, 1974; Beyers *et al.*, 1979; Gresse, 1991). Other similarities to the findings of other studies were:

- (a) The most frequently consumed vegetables were cabbage and stewed tomato and onions (Oudkerk, 1965; Franz, 1971; Gresse, 1991).

- (b) Fat and sugar were added to vegetables during cooking; potatoes were generally cooked with other vegetables, but, if cooked alone, served as mashed potatoes (Steenkamp, 1987; Gresse, 1991).
- (c) Pumpkin and beetroot salad were popular on Sundays and rice frequently replaced maize meal porridge at the Sunday meal (Manning *et al.*, 1974; Gresse, 1991).
- (d) The most popular types of fruit were apples, oranges and bananas (Oudkerk, 1965; Gresse, 1991).

A mixture of samp and dried beans was popular among the participants in the present study. This dish is typical of the Xhosa diet (Lubbe, 1971; Lubbe *et al.*, 1973; Manning *et al.*, 1974; Beyers, 1979), but has also been reported for Tswanas (Steenkamp, 1987). However, Gresse (1991) reported infrequent intakes of samp and beans in her study. This discrepancy could be due to the fact that the subjects in the study of Gresse were diabetics, and may not have been representative of a healthy population.

Meat was consumed in small amounts except for in Mmabatho. This is probably a reflection of availability and the economic status of the populations. Some of the participants in Moshawane owned cattle, but these were only slaughtered for ceremonial occasions, according to the Tswana tradition (Franz, 1971). There was also a notable difference in consumption of eggs between Mmabatho and the other areas. Eggs were used more frequently in Mmabatho, a similar finding to that of Gresse (1991) who reported an average intake of five eggs per week. Cheese was eaten by 54% of the IDDM patients and 62% of the NIDDM patients in the study of Gresse (1991), whereas it was only mentioned once by the Mmabatho subjects in the present study.

3.5.8 Implications with regard to the development of the quantitative food frequency questionnaire

From the results of the preliminary study, it is apparent that most participants consumed a fairly narrow variety of foods. This meant that the number of food photographs in the FPPB could be limited to 37 foods. However, wealthy participants in the urban areas did consume a wider

variety of foods and the exclusion of these might have produced bias in the data collected. The problem was how to develop a questionnaire that would be appropriate to both populations. In order not to bias the questionnaire, foods used by all groups had to be included in the QFFQ. However, photographs of less frequently consumed foods might not have been necessary. To estimate the portion sizes of these foods, available photographs of similar foods could be used and photographs of different sizes of serving utensils, cups and drinking glasses included.

Regarding the QFFQ itself, the questionnaire had to be designed so that it would be understood by the least educated participant, while not appearing too simple for the more sophisticated participants..

3.5.9 Implications for the nutrient content of foods

The preliminary study identified a number of foods either that do not appear in the existing South African food composition tables (Langenhoven *et al.*, 1991a), or for which the value in the tables may not be accurate, because of the preparation method. To address these problems, the recipes developed and confirmed in the preliminary study were coded and used for the dietary analysis. The nutrient values of food items which are listed in the food composition tables and which had a similar composition to those foods not listed were used for the nutrient analyses. For example, the analysis of spinach was used for *thêpê*.

3.6 CONCLUSION AND RECOMMENDATIONS

The preliminary study was conducted to gather information concerning the food habits and food related behaviours of the African population of the North West province to develop a culturally sensitive QFFQ. To achieve this, a combination of qualitative and quantitative research methodologies was used. The use of a qualitative methodology enabled the researcher not only to collect the data necessary for the development of the QFFQ and FPPB, but also to get to know the people living in the different areas. This experience was invaluable in both the planning and the implementation of the dietary intake study.

The following recommendations can be made regarding the use of a qualitative methodology:

- (a) More time should be spent in the study areas actually observing food procurement and preparation methods, as was done, for example, by Kigutha (1997).
- (b) Greater use should be made of triangulation to ensure that high quality data is collected. In the present study only methodological triangulation, that is, the use of in-depth interviews and focus groups, was used. However, there are other types of triangulations that could be applied to improve the rigour of the data (Janesick, 1994). Data triangulation refers to the use of a variety of sources of data, such as the use of interviews and participant observation, as suggested above. Several investigators collecting and interpreting the data would add rigour to the data. Interdisciplinary triangulation, as suggested by Janesick (1994), would greatly improve the quality of data collected. For example, a social anthropologist's information would increase the nutritionist's understanding of the culture and food habits of the population.

Whether the preliminary study achieved the objective of aiding the development of culturally sensitive QFFQ will only be assessed after the completion of the dietary intake study. This will be discussed in Chapter 9. The development of the food portion photograph book (FPPB) is described in detail in Chapter 4 and that of the QFFQ in Chapter 5

CHAPTER 4

THE DEVELOPMENT AND TESTING OF THE FOOD PORTION PHOTOGRAPH BOOK

4.1 SUMMARY

The construction of the food portion photograph book took place after the completion of the preliminary study. It was done concurrently with the development of the QFFQ. Data obtained on the most common foods, preparation methods and portion sizes were used to determine the photographs to be included in the food portion photograph book. Foods were prepared by the researcher and measured into three, or four, portion sizes. Colour photographs were taken of the food portions by a professional photographer under standard studio conditions. The photographs were enlarged to A4 size by photocopying and arranged so that all portions of one food could be viewed simultaneously. Each page was laminated. Initially, one book was put together and used in the pilot study. The pilot study showed that the food portion photograph book (FPPB) needed to be modified. After this was done sufficient copies were made for use in the dietary intake study.

The food portion photograph book was tested by presenting subjects with an actual portion of food. They were asked to estimate the portion size by matching it with one of the portion size photographs. The degree of accuracy was determined by the percentage difference between the estimated and the actual weight of the portion size.

The final food portion photograph book consisted of 37 foods, photographed in three or four portion sizes, and four photographs of utensils and cartons. The validity of the photographs was tested on a sample consisting of 169 adult volunteers from the North West province, who did not participate in the dietary intake study. Of the total of 2959 portion sizes tested, 68% were accurately estimated. Clearly defined solid foods such as fish, bread and boerewors were better estimated than foods which had an amorphous appearance (that is, foods with no definite shape or clearly defined boundaries) such as porridge and stew. With regard to the subjects' characteristics and their ability to estimate portion sizes, there were no significant differences

between genders, age groups or education levels.

The finding of a degree of accuracy of 68% compares well with the accuracy reported from other studies. Reasons for poor responses may be explained by the subjects' perceptions of the characteristics of the foods.

This chapter describes how the food photograph book was put together and tested, and discusses the results of the testing.

4.2 INTRODUCTION

4.2.1 Background to the problem

The purpose of any dietary intake study is to obtain the most accurate information regarding the habitual diets of the subjects. However, in order to give the required information, the subjects must not only recall what they have eaten, but also describe the amounts of food and drinks usually consumed. The researcher must then translate these descriptions into quantifiable amounts for nutrient analyses. In order to assist the subjects and to reduce the number of errors in quantifying portion sizes, a valid and simple way of assisting subjects to describe the amounts of food eaten is necessary. Various visual aids such as actual foods, food models, drawings and photographs of foods have been used in the past. Each has its own benefits and drawbacks. Unfortunately, there are few published reports on the use of visual aids in dietary intake studies and, as pointed out by Young and Nestle (1995) and Cypel *et al.* (1997), there is a need for research on the use of visual aids to assist portion size estimation. For a visual aid to be effective, the members of the target population must be able to understand and interpret it. An aid used in one population may not necessarily be appropriate for use in another population. Therefore, it is essential that a visual aid planned for use in a dietary intake survey be tested on members of the target population.

For the study on the dietary intakes of Africans in transition in the North West Province, it

was decided to develop a book of photographs of foods commonly eaten by the target population as an aid to the description of portion sizes. Each food was photographed in three portion sizes, based on the amounts usually eaten. The aim was to make the photographs as realistic in appearance and size as possible.

The question which arose was: would subjects be able to distinguish between the photographs of portion sizes and to relate their food portions to the photographs?

This chapter describes how the food portion photograph book was developed and tested for validity for use in the study on the dietary intakes of Africans in transition in the North West Province.

4.2.2 Aims

- (a) To determine whether subjects were able to estimate the size of a given portion of food by matching the actual food with a photograph of the food.
- (b) To determine whether individual characteristics, that is gender, age and education level influenced a subject's ability to estimate food portion sizes from photographs of the foods.

4.2.3 Hypotheses

- (a) Null hypothesis:

There is no significant difference between the true weight of a portion of a given food and the subjects' estimation of the portion size using a series of food portion size photographs.

Alternative hypothesis:

There is a significant difference between the true weight of a portion of a given food and the subjects' estimation of the portion size using a series of food portion size photographs.

(b) Null hypothesis

There is no significant difference between the ability of males and females to estimate the weight of a given portion size of a food using a series of food portion size photographs.

Alternative hypothesis

There is a significant difference between the ability of males and females to estimate the weight of a given portion of a food using a series of food portion size photographs.

(c) Null hypothesis

There is no significant difference between the ability of subjects of different ages to estimate the weight of a given portion of a food using a series of food portion size photographs.

Alternative hypothesis

There is a significant difference between the ability of subjects of different ages to estimate the weight of a given portion of a food using a series of food portion size photographs.

(d) Null hypothesis

There is no significant difference between the ability of subjects of different education levels to estimate the weight of a given portion of a food using a series of food portion size photographs.

Alternative hypothesis

There is a significant difference between the ability of subjects of different education levels to estimate the weight of a given portion of a food using a series of food portion size photographs.

4.2.4 Delimitations

The study only tested the subjects' abilities to match portions of actual food with one of the portion size photographs of that food. It did not test the subjects' abilities to recall portion sizes or to conceptualise portion sizes of foods. Also, it did not require the subject to judge the weight of a portion of food.

The study did not attempt to measure the subjects' abilities to estimate plate waste.

4.2.5 Operational definitions

- (a) Portion size: the weight of a given serving of food consumed by a single person at one time.
- (b) Actual food: real foods prepared and displayed on plates.
- (c) Accuracy: the degree to which the subjects' estimate of the size of a portion of the actual food using the food portion photographs was similar to the true weight of the food.

4.2.6 Importance of the study

The outcome of this study would indicate whether the food portion photograph book was an appropriate visual aid for use in the study on the dietary intakes of the African population of the North West Province.

4.3 METHODS

4.3.1 Development of the food portion photograph book

4.3.1.1 Trial photographs

As the first step in the production of the food portion photograph book, a trial set of colour photographs of nine foods, each in a small, medium and large portion size, was taken by a professional photographer under standard photographic studio conditions. The foods used were those eaten most frequently by the study population, namely: brown bread, stiff maize meal porridge, rice, a samp and bean dish, stewed meat with bone, cooked cabbage, cooked carrots, bananas and oranges.

The stiff maize meal porridge and stewed meat were photographed in 26 cm diameter enamel plates on a black background; the rice, samp and beans, cabbage and carrots were photographed in 16 cm enamel bowls, also on a black background; the bread was photographed on a black background and the fruit on a white background.

The photographs were enlarged from postcard size by photocopying in colour to A4 size (landscape orientation) and put into clear plastic pockets. These were first shown to two nutritionists to get their opinions on the appearance, the clarity, the difference between portion sizes and the feasibility of using the photographs as aids for food portion estimation. Thereafter, the photographs were shown to the participants in the focus groups of the preliminary study at the end of the discussions. The participants were asked to identify the foods and to indicate the small, medium and large portion sizes. They were also asked to comment on the appearance of the foods.

The focus group participants were able to recognise all the foods easily except the cabbage, which was identified, among others, as corn flakes and chicken. The cabbage had been cooked, according to custom for a long period, and therefore was brown in colour. Other comments on the photographs (from the nutritionists and the focus group participants) were:

- (a) The photographs of the medium and large stiff maize meal porridge portions had a pinkish colour due to incorrect lighting, which made them look unrealistic. One of the subjects said the porridge looked like 'pudding'.
- (b) The crusts of the bread merged with the black background, which made differentiating between the thickness of the slices very difficult.
- (c) The carrots were an unrealistically bright orange colour.
- (d) The small and medium bananas were too close in size to be able to distinguish between them.
- (e) The samp and bean dish did not resemble the samp and beans cooked by the subjects. The samp and beans were too 'separate'. The mixture for the photographs had been made by cooking the samp and beans separately and then mixing them together. However, the traditionally correct method is to cook the samp and beans together for a long time (up to six hours) until both are very soft and indistinguishable.
- (f) It was easier to distinguish between portion sizes of the foods photographed on the plates than of the foods photographed in the bowls.
- (g) All portion sizes must be shown simultaneously for subjects to see the differences between them.

4.3.1.2 Selection of foods and portion sizes for food portion photograph book

The decisions about the foods and portion sizes to be photographed were based on the results of the preliminary study. The most frequently mentioned foods were selected for inclusion in the food portion photograph book. Portion size weights were based on the means, standard deviations and minimum and maximum values of the portions served by the focus groups for

themselves, their husbands and their children older than 15 years of age. In most cases the mean (rounded to the nearest convenient number) was taken as the medium portion size. For the foods, such as vegetables, where small amounts were generally served, the small portion size was taken as the mean minus one standard deviation (SD) and the large portion size was taken as the mean plus one SD.

For example, the mean portion size for pumpkin was 45,6 g and the SD was 22,8 g. Thus the medium portion size was taken as 45 g, the small as $(45,6 - 22,8 = 22,8)$ taken to 25 g and the large size as $(45,6 + 22,8 = 68,4)$ taken as 70 g. The mean weight of brown bread was 68 g, the small $(68 - 19 = 39)$ was close to the weight of a standard pre-sliced slice of bread so that this weight (30 g) was taken as the small portion, while the large was taken as 100 g $(68 + 19)$ rounded up to 100 to make the difference between the medium and large portions more distinguishable).

Where portion sizes were generally large (porridge, samp and beans), the minimum was taken as the smallest portion size, the mean rounded up to the nearest convenient amount as the medium size and the large size as the mean plus two standard deviations. In the case of stiff maize meal porridge and samp and beans, which are known to be consumed in very large amounts, an “extra” large size of 700 g was added.

For example, for stiff maize meal porridge, the minimum was 220 g for the small size, the medium was the mean of 300 g and the large was 302 plus 130 (two SD), i.e. 450 (430 taken up to a more convenient size).

Before the photographs were taken, the prepared and weighed portions were examined to see if the differences in sizes were clearly visible. If not, the portion sizes were adjusted so that there were clear differences between sizes. Thus, in the case of stiff maize meal porridge, there was very little difference in appearance between the 220 and 300 gramme sizes. The small size was then taken down to 200 g, the medium size up to 350 g and the large to 500 g. For the above reason, the final photographed portion sizes (Table 4.1) did not correspond exactly to the descriptive statistics of the portions obtained in the preliminary study (Table 3.12).

The portion sizes of foods not included in the preliminary study were based on similar foods and standard sizes. The medium portion size for fried fish was the standard prepacked frozen hake fillet and the large size, the prepacked frozen whole hake. A whole canned pilchard was taken as the medium portion, half as the small and two whole fish as the large. Pieces rather than portion sizes were used for the chicken photographs.

The weights of the fruit portions depended on the available sizes of fruit at the time the photographs were taken with the researcher selecting weights close to the weights given for small, medium and large by the Food Quantities Manual of the Medical Research Council (Langenhoven *et al.*, 1991b). These tables were also used as guides for the weights of the portions of margarine, fried beef, corn on the cob (green mealie) and milk in tea and coffee.

In the case of biscuits and sweets, weights of commercial products were used. For cheese curls and peanuts, the weights of the standard packets (24 and 35 g respectively) were used for the medium size. The small and large sizes for peanuts were the amounts given in the Food Quantities Manual of the Medical Research Council (Langenhoven *et al.*, 1991b) for a level tablespoon and half a cup (125 ml). The small size for cheese curls was approximately half the standard packet weight and the large, double the standard packet weight.

In addition to the foods, photographs were taken of drinking glasses in various sizes (150, 250, 225 and 350 ml), cups and mugs (180, 220 and 300 ml), spoons (2, 5, 10, 15 and 30 ml) and cartons used for mageu and sorghum beer.

4.3.1.3

Preparation and photographing of the foods

All foods were prepared by the researcher. Mixed dishes were prepared following the recipes derived from the preliminary study. Portion sizes were weighed on an EKS 36 (France) diet scale (five gramme divisions, capacity of 500 g). Prepared and weighed foods (each portion in an individual container) were taken to the photographer's studio where the portion sizes were placed on 26 cm diameter yellow enamel plates before being photographed. The photographer assisted with the arrangement of the food on the plates.

Colour photographs of each food in three portion sizes (four in the cases of stiff maize meal porridge and samp and beans) were taken by the professional photographer under standard photographic conditions. Each portion size was photographed separately except for polony, apples, bread, bread spread with margarine, dumpling, biscuits and sweets for which all portions were taken on one photograph. The three portion sizes of margarine (5 g, 10 g and 15 g) were photographed spread on a 60 g slice of brown bread.

Based on the comments made on the trial photographs, the following steps were taken to ensure that the photographs would be as clear and realistic as possible:

- (a) The lighting was adjusted so as not to affect the natural colour of the food.
- (b) 26 cm enamel plates were used for all foods served on plates.
- (c) The plates were placed on a black background.
- (d) The fruit was photographed on a white background.
- (e) The dumpling, bread and bread spread with margarine were placed on a light brown wooden board for contrast.
- (f) The photographs were taken at a 45° angle to simulate the approximate angle at which food is viewed when placed in front of a person.

4.3.1.4 Production of the food portion photograph book

The photographs were printed in landscape orientation in colour in postcard size (10 x 15 cm). To obtain pictures as close to life size as possible, the prints were enlarged by colour photocopying to A4 size (21 x 29,5 cm). The diameter of the plate in the enlarged photograph was 20,5 cm (approximately 80% of the actual size). Each photograph was labelled with the name of the food or utensil in English, Afrikaans and Tswana and the weight in grammes.

The photographs were then sorted into the order in which the foods appeared in the QFFQ. The small portion of each food was placed on the left, the medium portion in the centre (on one A3 page) and the large size on the right (on the left-hand side of an A3 page). The pages were laminated for firmness and protection and spiral bound on the left-hand side. Thus, when

the book was opened all portion sizes could be seen at the same time. The final book measured 41 x 30 x 1,5 cm (excluding binding) when closed. Figure 4.1 shows the final bound food portion photograph book and Figure 4.2 the open book displaying the four portions of samp and beans. Figures 4.3 to 4.5 show the photographs of the portions of stiff maize meal porridge, meat stew and fat cakes as examples of the photographs.

4.3.1.5 Modifications made to the food portion photograph book

The food portion photograph book was used together with the QFFQ in a pilot study of ten Tswana speaking volunteers (seven females and three males) to test the clarity and completeness of the QFFQ and whether the photographs assisted the subjects to estimate their food portion sizes. In addition, subjects were asked to comment on the photographs. The subjects were interviewed with the assistance of a Tswana speaking interpreter.

All subjects found the photographs helped them to describe their food intake and only a few changes were necessary. These being:

- (a) The inclusion of soft maize meal porridge in three portion sizes. As soft maize meal porridge was not used in the preliminary study, the portion sizes were taken to be the same as the small, medium and large stiff maize meal porridge size (200, 350 and 500 g).
- (b) The pumpkin was photographed again, as the first photograph was unrealistic (some of the subjects said that it resembled raw meat).

**THE NUTRITION TRANSITION
AMONG THE AFRICAN
POPULATION OF NORTH WEST**

FOOD PORTION SIZES

Developed by: U E MacIntyre

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Dept Dietetics and Family Ecology

Potchefstroom University for CHE

1996

Figure 4.1: The final bound food portion photograph book

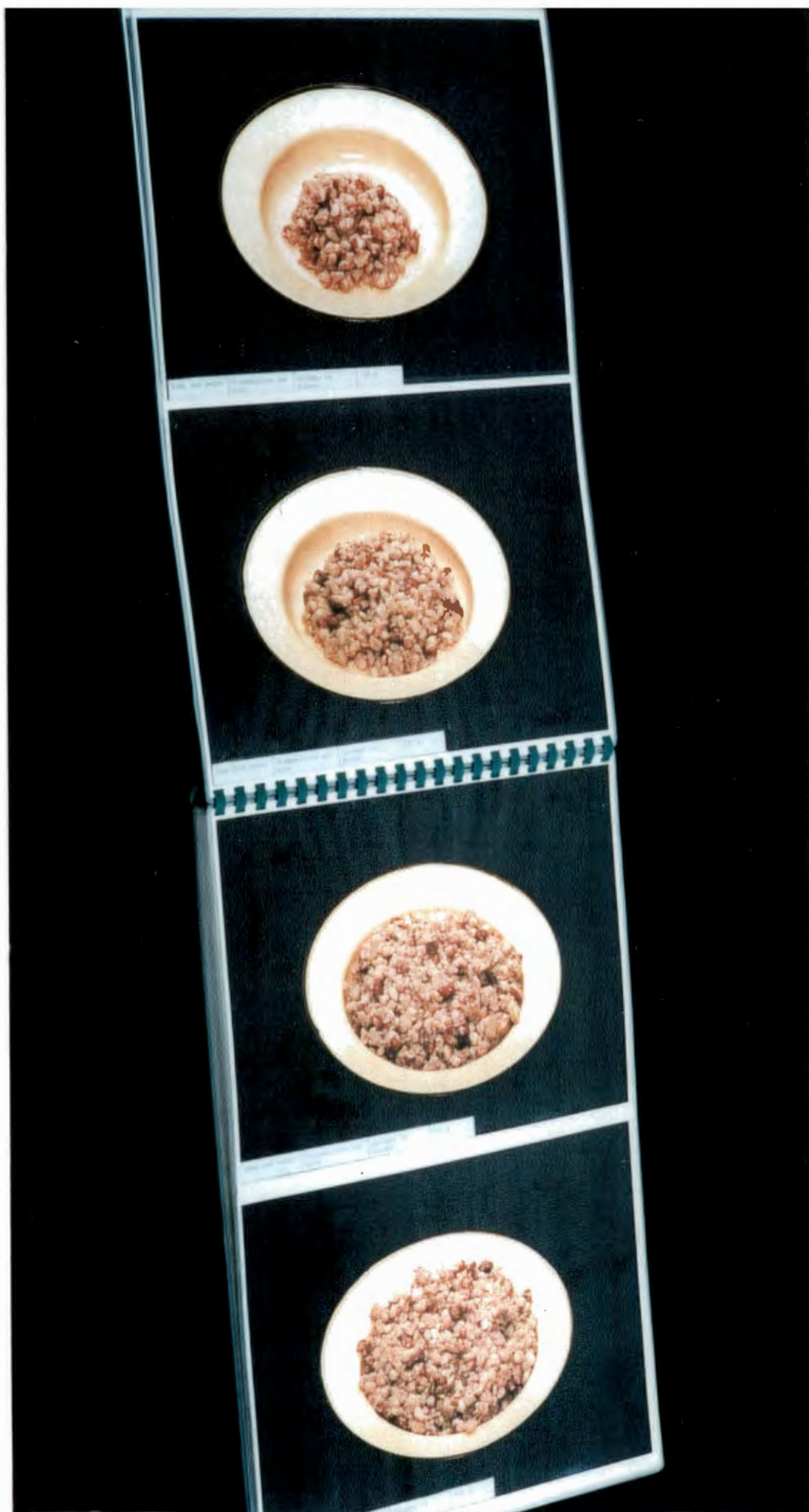


Figure 4.2: The food portion photograph open to display the four portion sizes of salmon and beans

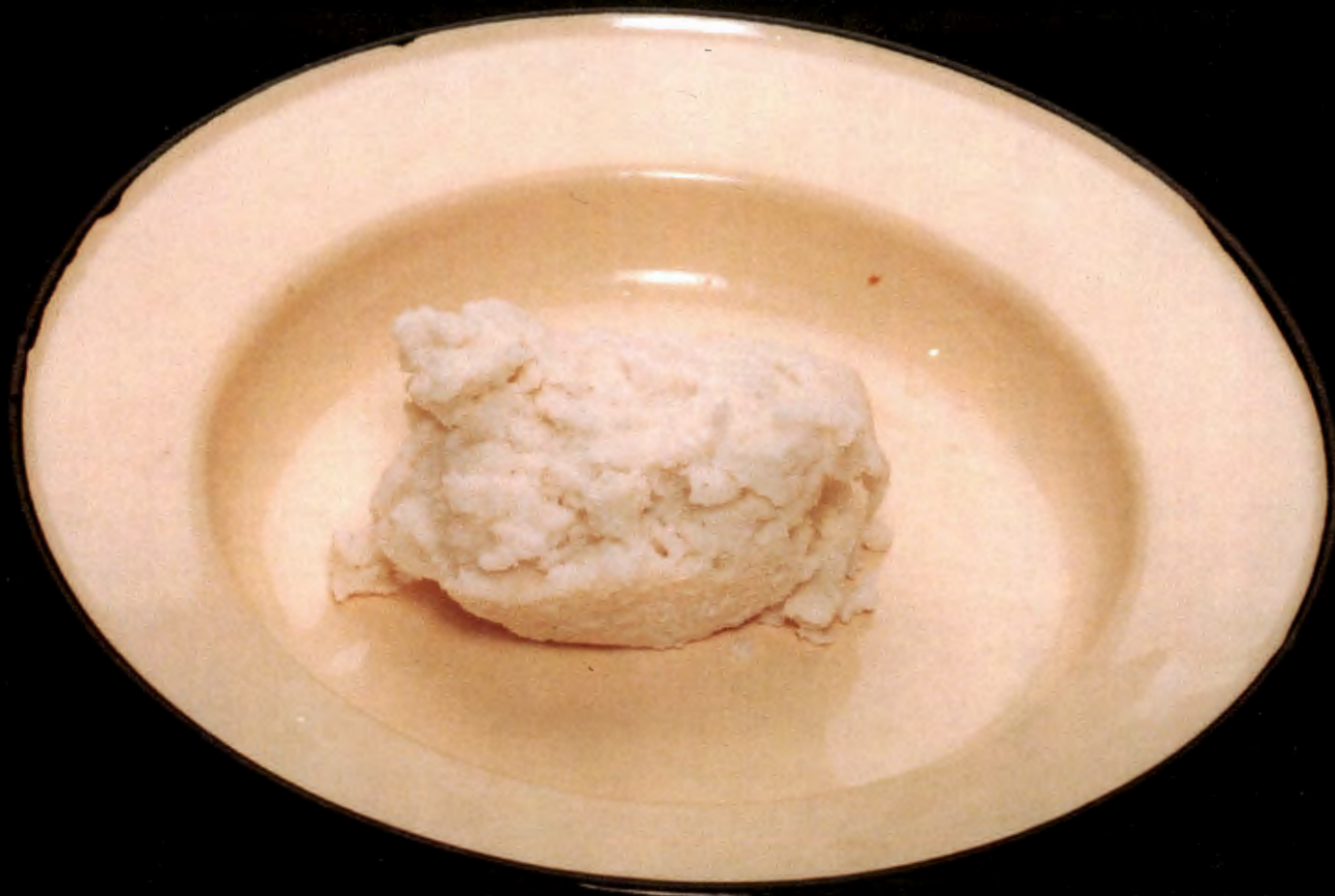


Figure 4.3a: Stiff maize meal porridge - 200 g portion



Figure 4.3b: Stiff maize meal porridge - 350 g portion



Figure 4.3c: Stiff maize meal porridge - 500 g portion



Figure 4.3d: Stiff maize meal porridge - 700 g portion



Figure 4.4a: Meat stew - 110 g portion



Figure 4.4b: Meat stew - 220 g portion



Figure 4.4c: Meat stew - 330 g portion

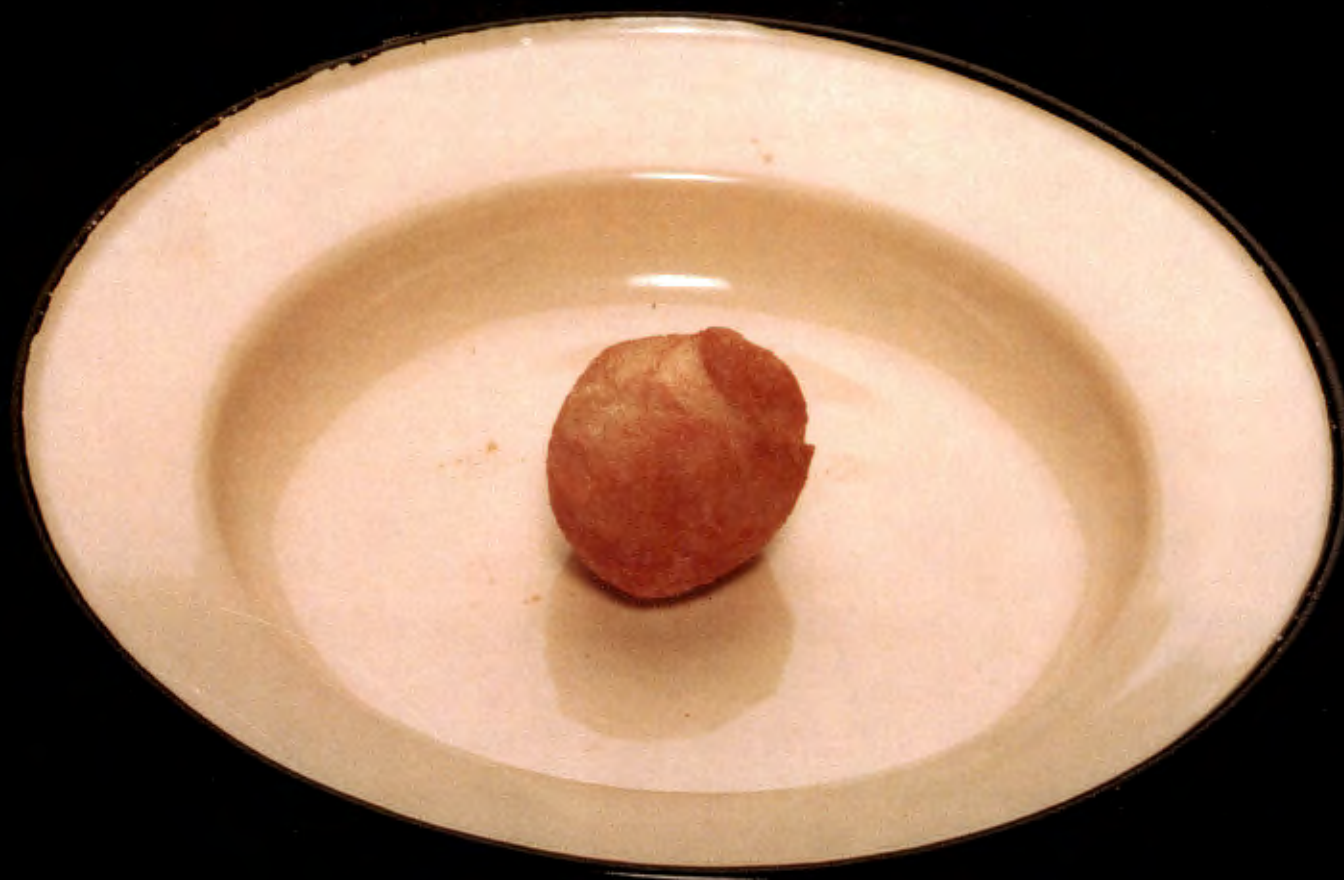


Figure 4.5a: Fat cake - 35 g portion

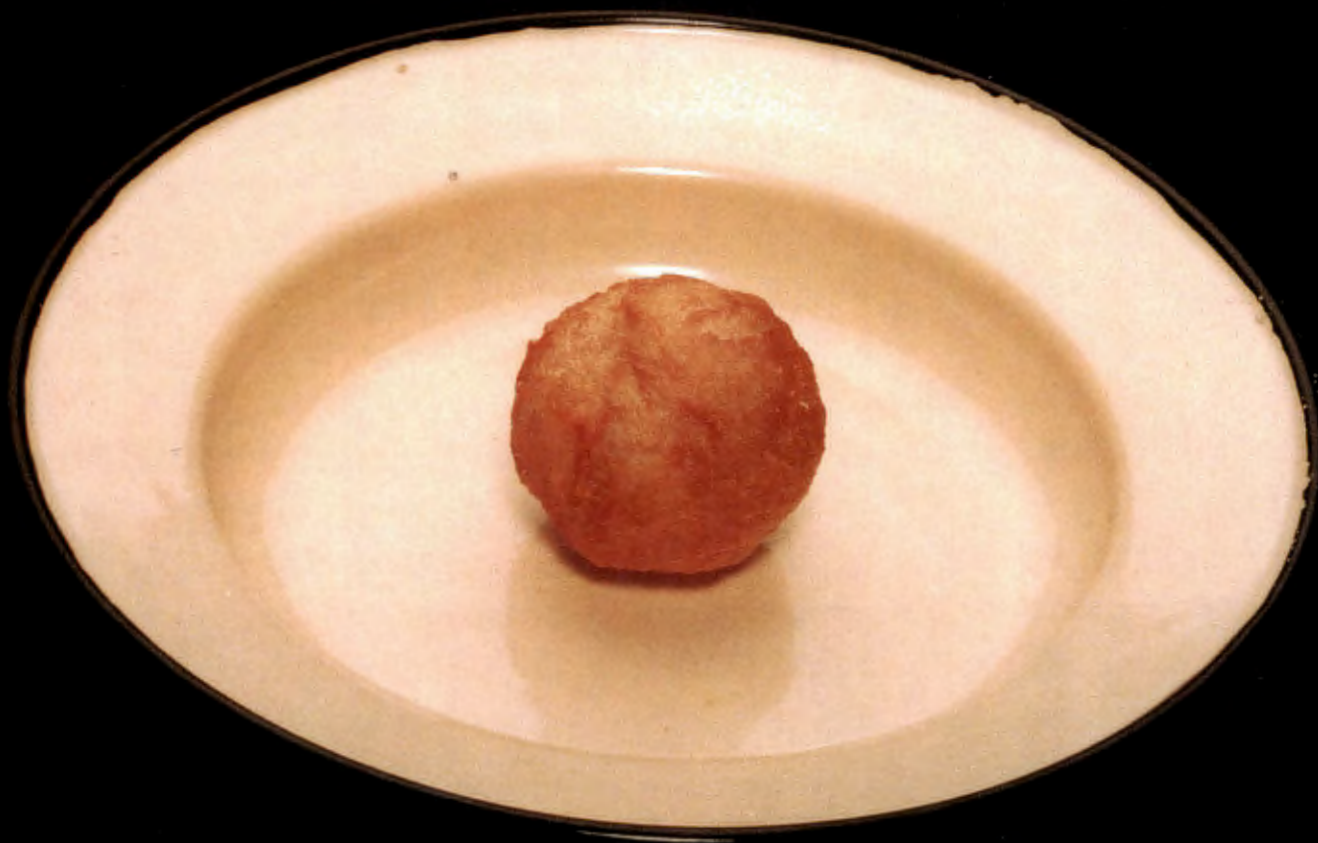


Figure 4.5b: Fat cake - 60 g portion

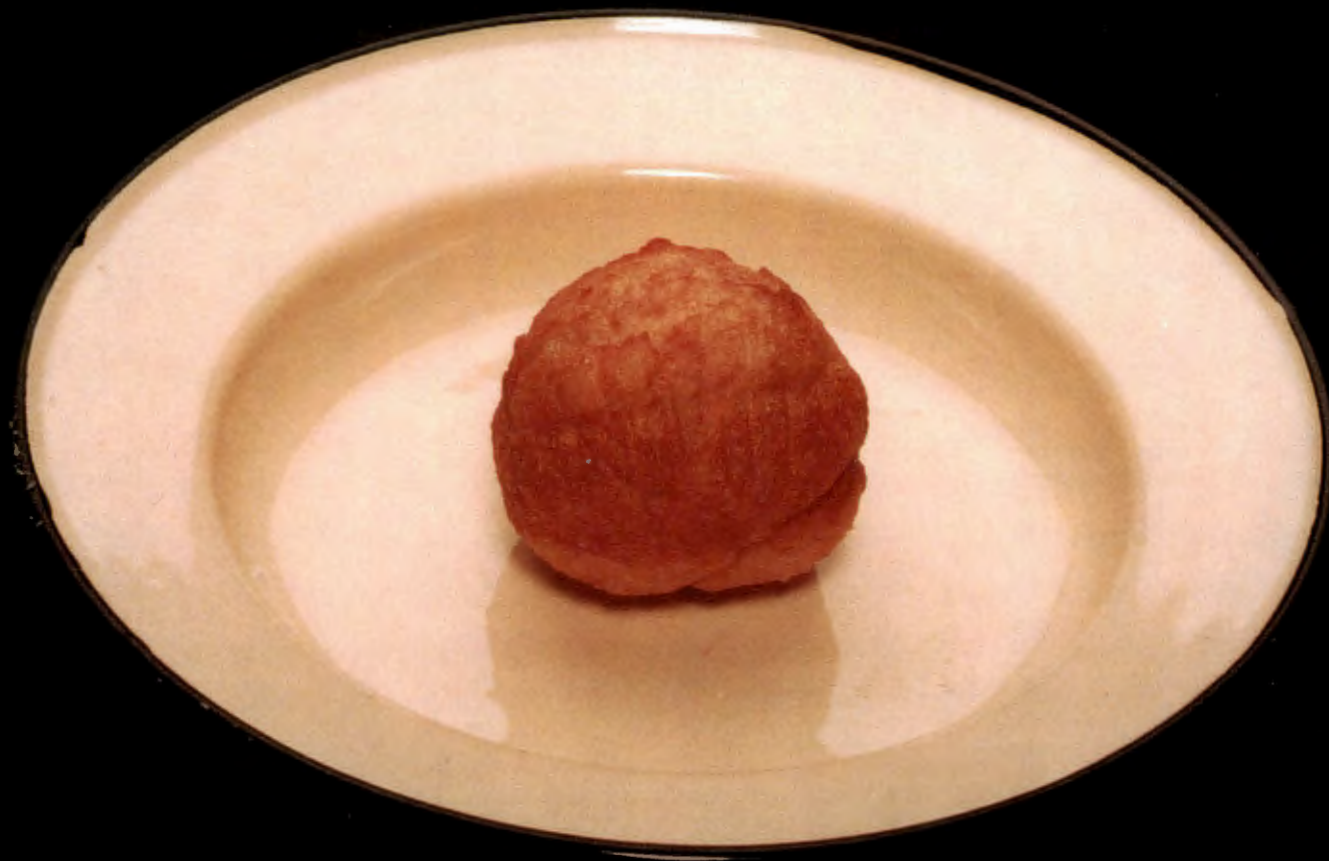


Figure 4.5c: Fat cake - 80 g portion

4.3.1.6 The final food portion photograph book

Once the above changes had been made, nine copies of the book were put together as described above. The final food portion photograph book consisted of photographs of 37 foods. In addition, four photographs depicting different sizes of cups and mugs, drinking glasses, spoons and beverage cartons were included. All weights were given for the edible portion of the food. All foods were presented in three portion sizes (small, medium and large), with the following exceptions:

- (a). A fourth, 'extra' large portion size was included for stiff maize meal porridge and samp and beans, to allow for the very large amounts consumed of these foods.
- (b) Pieces of chicken were used as portions
- (c) Sweets and biscuits were arranged on plates and photographed in common commercial sizes.

Table 4.1 presents the photographs and portion sizes of the foods and the utensils included in the food portion photograph book, in the order in which they appeared in the book.

Table 4.1: Photographs and portion sizes included in the food portion photograph book

Photograph	Size (g)			
	Small	Medium	Large	Extra large
Cups and mugs (ml)	180	220	300	
Drinking glasses (ml)	150	225	250	350
Spoons (ml)	2 and 5	10	15	30
Milk in tea	10	20	30	
Milk in coffee	20	40	60	
Stiff maize meal porridge	200	350	500	700
Soft maize meal porridge	200	350	500	
Samp and beans	150	250	500	700
Rice	90	125	250	
Chicken wing	30			
Chicken thigh	45			
Chicken breast	45	95		
Chicken feet	16	32		
Fried beef	30	60	100	
Fried beef with bone	60	90	150	
Meat stew	110	220	330	
Offal (intestines)	60	80	120	
Boerewors	35	60	120	
French polony	10	20	35	
Canned pilchards, whole	30	60	120	
Canned pilchards mashed with onion	30	60	180	
Fried fish	60	80	130	
Cabbage, potato and onion	30	60	90	
Spinach and potato	30	60	90	
Tomato and onion sauce	20	40	80	
Pumpkin	25	45	70	
Carrots and potato	55	70	85	
Green mealie	80	140	220	
Beetroot salad	20	40	70	
French fries	60	120	250	

Photograph	Size (g)			
	Small	Medium	Large	Extra large
Banana	60	75	110	
Apple	100	160	230	
Orange	120	180	220	
Canned peaches	50	90	130	
Custard with canned peaches	10	25	50	
Dumpling	40	100	150	
Brown bread	30	60	100	
Margarine spread on bread	5	10	15	
Atchar	25	65	100	
Fat cakes	35	60	80	
Cheese curls	10	24	50	
Peanuts	10	35	80	
Mageu carton (ml)	500			
Sorghum beer carton (ml)	1000			
Sweets and chocolates:				
Hard sweet	7	100 (slab)		
Milk chocolate	5			
Liquorice all sorts	5			
Fruit pastille	5			
Toffee	5			
Biscuits				
Plain biscuit	10			
Wafer	10			
Chocolate biscuit	10			
Double biscuit with filling	15			

It was impossible to include all foods eaten by the study population in the food portion photograph book. Therefore a guide was drawn up so that one set of food photographs could be used to represent several foods with a similar appearance. For example, the photographs of soft maize meal porridge could be used for oats or sorghum porridge and the mashed pilchards could also represent minced meat or soya mince. This guide was included as a table in the field workers' instruction manual. To extend the range of portion sizes, subjects would be instructed that if their portions did not match those in the photographs, they could indicate that the portion was:

- (a) smaller than the small size (A)
- (b) between the small (A) and the medium (B)
- (c) between the medium (B) and large (C)
- (d) between the large (C) and extra large (D) (stiff maize meal porridge and samp and beans)
- (e) larger than the largest portion (C or D).

The calculation of the above portion sizes was based on the guidelines given by Lucas *et al.* (1995). For intermediate portion sizes (between small and medium or between medium and large) the weight was calculated as the average of the two adjacent weights (e.g. $(A+B)/2$). For a response 'smaller than the small' or 'larger than the large', the weight was estimated by subtracting half the adjacent interval from the smallest weight ($A-(B-A)/2$) or adding half the adjacent weight category to the largest portion size weight. The formulae used for the calculations are shown in Table 4.2

Table 4.2: Calculation of intermediate portion sizes

Portion size	Weight calculation*
Smaller than A	$WA - (WB-WA)/2$
Between A and B	$(WA + WB)/2$
Between B and C	$(WB + WC)/2$
Larger than C (no extra large size)	$WC + (WC-WB)/2$
Between C and D	$(WC + WD)/2$
Larger than D	$WD + (WD-WC)/2$

*A, B, C and D refer to the small, medium, large and extra large portion sizes respectively. WA, WB, WC and WD refer to the weights of the portion sizes used in the photographs.

4.3.2 Testing of the food portion photograph book

The objectives of this part of the study were:

- (a) To test whether subjects could recognise types of foods from the photographs.
- (b) To assess whether subjects could estimate a portion size by matching the actual food to a food portion photograph.

A similar study was reported by Lucas *et al.* in 1995 and was used as a guide in the planning of the present study. In order to eliminate the effect of memory, subjects were shown plates of actual food corresponding to one of the portion sizes in the food portion photograph book. The subjects were then asked to match the actual food with one of the photographs and their response recorded.

4.3.2.1 Pilot study

The pilot study was conducted with 23 volunteers from a church in the North West Province as subjects. A record form was drawn up to record age, gender and education level as well as the subject's responses (Appendix E).

To test whether the photographs were recognisable, subjects were asked to identify eight to 10 photographs and their answers were recorded. They were then shown the portion of actual food together with the full range of food portion photographs for that food and asked to match the actual food to one of the photographs. Each subject was shown 10 foods. Only one portion of a particular food was shown to each subject and foods were presented to subjects one at a time. The interviews were conducted privately so that subjects could not influence each other or see the foods before they were tested. Different foods were used for the food identification section and the portion matching section.

Tswana speaking volunteers were recruited from the church to be interviewers. The interviewers were trained by the researcher to conduct the interviews and record the responses. The interviewers worked in pairs, one showing the photographs and foods and the other recording the subjects' answers. There were four pairs of interviewers with each pair testing five or six subjects. Each interview took five to 10 minutes.

Subjects had difficulty in identifying some of the food photographs. Table 4.3 shows the foods which were incorrectly identified. All foods were mistaken by one subject each, except fried beef which was mistaken for fish by two subjects.

Table 4.3: Foods incorrectly identified in the pilot study

Food	*Identified as:
Stiff maize meal porridge	Mashed potatoes
Soft porridge	Soup
Samp and beans	Minced meat
Fried beef	Chicken Fish Sausage
Spinach	Dried meat
Pumpkin	Jam
Beetroot salad	Pudding

*Descriptions as given by the subjects

It was decided not to ask respondents to identify the foods in the photographs during the interview for the following reasons:

- (a) In the context of the QFFQ interview, the interviewer would identify the food.
- (b) As mentioned above (4.3.1.5), one type of food could be used to represent several other foods as well.
- (c) Leaving out the identification would allow time to test more portion sizes which was the most important part of the study.

No changes were necessary with regard to the record form or the procedure followed for the portion size test. Thus, these subjects' responses were used with those of the actual study.

4.3.2.2 Sample selection

A sample of convenience was used by recruiting 146 volunteers, 15 years of age or older, at clinics in the North West Province (Phedisong 1, Phedisong 4 and Phedisong 6 in Ga-Rankuwa and the Oukasie clinic in the Brits area) and from the Lodger Mother Unit (LMU) at Ga-Rankuwa Hospital. Permission was sought and granted from the appropriate authorities. The only exclusion criterion was the inability to see well, or blindness. Although the sample was not stratified, the clinics were selected in such a way as to provide a cross-section of age and education levels. Table 4.4 shows the number of subjects interviewed at each testing session.

Table 4.4: Number of subjects tested per testing session (N=146)

Clinic	Number of subjects
Oukasie clinic	32
Lodger Mother Unit	21
Phedisong 1	29
Phedisong 4	32
Phedisong 6	32
Total	146

4.3.2.3 Selection and preparation of the food portions

The photographs selected for testing were those of the most commonly used foods. Foods for which it was easy to describe portion sizes, such as commercial biscuits, sweets and chocolates, and chicken pieces were not included in the test photographs.

Foods and portion sizes were randomly assigned to each testing session. For practical reasons the same foods and portion sizes were shown to all subjects in a group at a testing session, except the last session at the Phedisong 6 clinic, where some portion sizes were changed half way

through the session to ensure coverage of all portion sizes. Each subject was shown only one portion size of a given food. For example, all subjects at the Oukasie clinic were shown the 500 g portion of stiff maize meal porridge. Between 16 and 20 foods were shown to each group. In all, 20 of the 37 foods photographed were tested. For stiff maize meal porridge and samp and beans, four portion sizes were tested. For the other foods, three portion sizes were tested. Thus, a total of 62 portion sizes were tested. Table 4.5 shows how the foods and portion sizes were randomly allocated to each testing session.

Table 4.5: Random allocation of food portion photographs to testing sessions (N=146)

Food	Oukasie N=32	*LMU N=21	Phedisong 1 N=29	Phedisong 4 N=32	Phedisong 6 N=18	Phedisong 6 N=14
Stiff maize meal porridge	C	A	B	A	D	D
Soft maize meal porridge	A	B	C	B	A	C
Samp and beans	D	C	A	C	B	B
Rice	-	-	B	C	A	A
Fried beef	C	A	B	A	B	C
Meat stew	A	C	B	C	A	B
Boerewors	-	B	A	B	C	C
Pilchards whole	A	A	C	A	B	B
Pilchards mashed	B	A	C	A	B	C
Fried fish	B	A	C	A	B	B
Cabbage	A	B	C	B	C	C
Spinach	C	A	B	A	B	B
Tomato and onion sauce	B	C	A	C	A	A
Pumpkin	C	B	A	B	A	A
Beetroot	A	C	B	C	B	B
Apple	A	B	C	B	C	C
Dumpling	B	A	C	A	C	C
Bread with spread	B	C	A	C	A	B
Bread	-	B	C	B	A	A
Fat cakes	-	C	A	C	B	B

*Lodger Mother Unit, Ga-Rankuwa Hospital

A - small portion size; B - medium portion size; C - large portion size; D - extra large portion size (for weights of portion sizes see Table 4.1).

All foods were prepared by the researcher, following the recipes for mixed dishes. The food portions were weighed on the same scale used for the weighing of portions for the photographs. The foods were then placed on plates in such a way as to resemble the photographs as closely as possible. For example, not only were the weights of portions of foods such as fried beef, fried fish and fat cakes kept the same, but also the dimensions. All food portions corresponded with the exact weight of the portion in the photograph. For practical purposes, plastic plates of the same size and dimensions as the enamel plates were used to display the foods. All the plates were covered with plastic wrap. Foods not served on plates in the photographs (bread, bread spread with margarine, apples) were wrapped in plastic. The prepared and weighed food portions were transported to the various clinics and the LMU.

4.3.2.4 Test procedure

The interviews were conducted by a Tswana speaking interviewer, who was familiar with the Ga-Rankuwa and Oukasie communities. Before the first test, the interviewer was trained by the researcher. Subjects were interviewed individually. The interviewer explained the purpose of the test and told the subject what to do. She then showed the subject the actual food and the food portion photographs of that food. The subject indicated his or her response by pointing to one of the photographs. If subjects thought that a portion did not correspond exactly with one of the photographs, they could indicate that it was smaller than the small, larger than the largest size, or between the small and medium or medium and large sizes. The subjects were not told the weight of the portion. The interviewer did not know the correct answers. Actual foods and photographs were presented in the order in which they appeared in the food portion photograph book.

The responses were recorded by the researcher on the record form, using A to indicate small, B medium, C large and D extra large (Appendix E). Subjects were asked their age and education level at the end of the interview. Subjects were allowed as much time as they needed. Each interview took five to ten minutes. All subjects were given a token of appreciation at the end of the interview (fruit or a packet of dried beans).

4.3.2.5. Statistical analysis

Frequency distributions and descriptive statistics (mean, standard deviation (SD) and 95% confidence intervals) were used to describe the characteristics of the sample and the responses of the subjects.

The number and percentage of portions correctly identified, overestimated and underestimated were calculated for each subject and for each portion of each food. The percentages of correct, overestimated and underestimated portions were compared for age, education and gender groups using the one way analysis of variance (ANOVA) test and the post hoc Tukey test for honest significant differences (Statsoft, 1995) with a significance level set at $P=0,05$.

The mean estimated weight and 95% confidence interval were calculated for each portion size of each food and the estimates were tested against the actual weight of each portion using the Wilcoxon test, also with a significance level set at $P=0,05$. For responses corresponding to a given photograph, the exact weight of the portion in the photograph was used. For intermediate responses, such as 'between small and medium' or 'smaller than the smallest', the procedure described in 4.3.1.5 and Table 4.2 was followed.

The percentage difference between the average estimated weight and the actual weight of each portion size of each food was calculated using the formula: $\text{percentage difference} = [(\text{estimated weight} - \text{actual weight}) / \text{actual weight}] \times 100$.

All statistical calculations were performed using the Statistica for Windows (Statsoft, 1995) programme.

4.4 RESULTS OF THE PHOTOGRAPH TESTING STUDY

4.4.1 Sample description of the photograph testing study

The final sample for the food photograph validation study consisted of 169 (23 +146) subjects, 39 (23%) of whom were males and 130 (77%) females. All the subjects were Tswana speakers from the Odi and Brits areas of the North West province. The mean age of the sample was 36 years (SD=16,5 years). Table 4.6 shows the frequency distribution according to age and sex and Table 4.7, the frequency distribution according to educational level.

Table 4.6: Frequency distribution according to age and gender (N=169)

Age (years)	Gender				Total	
	Males		Females		N	%
	N	%	N	%		
15 - 24	14	36,0	43	33,1	57	33,7
25 - 34	7	17,9	33	25,4	40	23,7
35 - 44	10	25,6	13	10,0	23	13,6
45 - 54	2	5,1	12	9,2	14	8,3
55 - 64	4	10,3	22	16,9	26	15,4
>= 65	2	5,1	7	5,4	9	5,3
Total	39	100	130	100	169	100

Table 4.7: Frequency distribution according to education level (N=169)

Education level	N	%
No schooling	9	5,3
Grade 1 - *Std 2	6	3,6
Std 3 - Std 5	25	14,8
Std 6 - Std 8	59	34,9
Std 9 - Std 10	53	31,3
Post school	17	10,1
Total	169	100

*Std = highest school standard passed

The majority of the subjects were in the younger age groups (57% younger than 35 years of age). Similarly, most of the subjects (76%) had at least a standard 6 education, while only nine per cent had no education or had attended school for less than five years.

4.4.2 Pattern of responses

Table 4.8 shows the number of correct, overestimated and underestimated responses for each food and portion size. Of the total of 2959 responses, 2026 (68%) were correct, 444 (15%) overestimated and 489 (16%) underestimated. The highest numbers of correct responses (more than 80%) were obtained for boerewors, fried fish, apple and dumpling, all of which were presented as clearly defined solid pieces of food. On the other hand, the poorest responses (less than 60% responses correct) were obtained for soft porridge, samp and beans, cabbage and margarine spread on bread, all fairly amorphous foods (semi-solid or mixed foods which are less resistant to flow than solid foods but more resistant to flow than liquid foods). A significantly higher percentage of correct responses were given for solid foods (77%) than for the amorphous types of foods (63%) ($P < 0,0001$).

The foods most frequently (more than 25%) overestimated were soft porridge, samp and beans, pumpkin and margarine spread on bread, whereas fried beef, boerewors, cabbage and dumpling were seldom overestimated. Cabbage and tomato and onion sauce were the foods most frequently underestimated. Amorphous foods were over- and underestimated to the same extent (18,3% and 18,9% of responses respectively), while solid foods were significantly more frequently underestimated (13% of responses) than overestimated (9,8% responses) ($P < 0,05$). Overestimation occurred more frequently for amorphous foods (18,3% of responses) than for solid foods (9,8% of responses) ($P = 0,0$). Likewise, amorphous foods were underestimated significantly more frequently (19% of responses) than solid foods (13,8% of responses) ($P = 0,0$).

Although subjects were told that they could indicate that a portion was smaller than the small portion or larger than the largest portion, no subjects actually did so. Thus all the incorrect responses to the small portion sizes were overestimations and all the incorrect responses to the largest portion sizes were underestimations. With regard to the medium size, there was a slightly greater tendency to underestimate than to overestimate the portion sizes (21% under - and 19%

overestimated).

Foods for which the medium size was more frequently overestimated than underestimated were: stiff maize meal porridge, soft maize meal porridge, spinach, pumpkin and margarine spread on bread, all amorphous foods. No subjects overestimated the medium size of cabbage, while only one subject overestimated the medium portions of fried beef, whole pilchards and tomato and onion sauce.

Key to Table 4.8

A, B, C, D refer to the small, medium, large and extra large portion sizes respectively

T, C, O, U refer to the total number, the number correct, the number overestimated and the number underestimated for each portion size of each food photograph.

Table 4.8: Correct, overestimated and underestimated responses for each portion size of each food(N=2959)

FOOD	A				B				C				D				TOTAL			
	T	C	O	U	T	C	O	U	T	C	O	U	T	C	O	U	T	C %	O %	U %
¹ Stiff porridge	60	53	7		36	12	19	5	39	19	9	11	34	22		12	169	106 63	35 21	28 17
¹ Soft porridge	49	32	17		56	24	24	8	41	25		16					146	81 56	41 28	24 16
¹ Samp and beans	34	22	12		36	20	16	0	58	32	15	11	40	20		20	168	94 56	43 26	31 18
¹ Rice	29	24	5		29	18	3	8	33	20		13					91	62 68	8 9	21 23
² Fried beef	58	53	5		54	35	1	18	49	36		13					161	124 77	6 4	31 19
¹ Stew	49	37	12		41	32	4	5	56	40		16					146	109 75	16 11	21 14
² Boerewors	37	34	3		58	43	2	13	37	32		5					132	109 83	5 4	18 14
² Pilchards whole	86	62	24		31	25	1	5	29	27		2					146	114 78	25 17	7 5
¹ Pilchards mashed	55	44	11		50	37	4	9	41	32		9					146	113 77	15 10	18 12
² Fried fish	54	44	10		60	43	7	10	29	28		1					143	115 80	17 12	11 8
¹ Cabbage	38	34	4		63	27	0	36	60	24		36					161	85 53	4 2	72 45
¹ Spinach	56	38	18		58	36	16	6	32	20		12					146	94 64	34 23	18 12
¹ Tomato and onion sauce	66	59	7		37	8	1	28	63	34		29					166	101 61	8 5	57 34
¹ Pumpkin	60	36	24		63	35	21	7	37	32		5					160	103 64	45 28	12 8
¹ Beetroot	31	15	16		58	37	19	2	56	45		11					145	97 67	35 24	13 9
² Apples	36	31	5		65	43	10	12	66	63		3					167	137 82	15 9	15 9
² Dumpling	58	57	1		40	38	2	0	63	37		26					161	132 82	3 2	26 16
¹ Bread with spread	48	20	28		44	20	16	8	54	37		17					146	77 53	44 30	25 17
² Bread	37	21	16		60	41	8	11	30	27		3					127	89 70	24 19	14 11
² Fat cakes	36	22	14		32	17	7	8	64	45		19					132	84 64	21 16	27 20
	977	738	239		971	591	181	199	937	655	24	258	74	42		32	2959	2026 68	444 15	489 17

¹ Amorphous foods ² Solid foods

The mean estimated weight, percentage difference of the estimated weight from the actual weight and the 95% confidence intervals for all foods tested by portion size are shown in Table 4.9. A percentage difference of zero would be a perfect score.

Table 4.9: Actual weights, mean estimated weights, degree of accuracy and 95% confidence intervals for all food portions tested

Food	¶N	Actual weight g	†Estimated weight g	‡Difference %	95% Confidence interval	P-Value
Two portions correctly estimated: medium and large (small overestimated)						
Fried fish	54	60	65,6	9,3	61,7 - 69,5	**
	60	80	82,5	3,1	77,7 - 87,3	NS
	29	130	125,3	-3,6	118,7 - 132,0	NS
Pilchards, whole	86	30	39,1	30,3	35,6 - 42,5	***
	31	60	56,3	- 6,2	51,4 - 60,8	NS
	29	120	114,8	- 4,3	107,3 - 122,3	NS
Apple	36	100	108,3	8,3	101,2 - 115,5	*
	65	160	159,6	- 0,3	150,3 - 169,1	NS
	66	230	226,8	-1,4	223,2 - 230,4	NS
Bread	37	30	46,2	54,0	39,0 - 53,4	***
	60	60	59,8	- 0,3	54,8 - 64,9	NS
	30	100	94,8	- 5,2	88,7 - 101,0	NS
Two portions correctly estimated: small and medium (large underestimated)						
Boerewors	37	35	36,7	4,9	34,7 - 38,7	NS
	58	60	55,8	-7,0	51,3 - 60,2	NS
	37	120	109,7	-8,6	100,8 - 118,7	*
Rice	29	90	96,0	6,7	90,9 - 101,2	NS
	29	125	128,3	2,6	111,3 - 145,3	NS
	33	250	195,5	-21,8	170,8 - 220,1	**

¶N: number of subjects tested for each portion; † Estimated weight: mean of all observations per food per portion
‡ Difference %: difference between the estimated and the actual weight as a percentage of the actual weight
Significance of the difference between estimated and actual weights: NS P>0,05;
* P<0,05; ** P <0,01; *** P<0,001

There were no foods for which all portion size estimates did not differ significantly from the actual weights of the food portions. For four foods (fried fish, whole pilchards, apple and bread), the medium and large portion sizes were accurately estimated (error less than 7%) but the small portion sizes were significantly overestimated ($P<0,05$). For three foods (boerewors, rice and dumpling), the small and medium portions were accurately estimated (error less than 10%), while the large portion size was significantly underestimated ($P<0,05$). For cabbage, the small portion size was correctly estimated, while the medium and large portion sizes were underestimated ($P=0,0$).

For seven of the remaining foods, the errors were substantial for the small and large portion sizes ($P<0,05$), but not for the medium portion size. Significant errors occurred in the estimated weights of all three portions of the five other foods. For these foods, small portion sizes were overestimated by 10,5 to 86% ($P<0,05$) while large portion sizes were underestimated by 7,5 to 27% ($P<0,05$). Medium portions were significantly underestimated by 16% and 35% for fried beef and tomato and onion sauce respectively ($P<0,01$). The medium portion sizes of soft porridge, pumpkin and beetroot were significantly overestimated by 12 to 23% ($P<0,05$).

The two foods with four portion sizes (stiff maize meal porridge and samp and beans) showed similar patterns of responses, although the magnitude of the differences was greater for the samp and beans. In both cases the 500 g portion sizes (large) were very accurately estimated ($P>0,5$) (no difference for stiff maize meal porridge and 1,2% difference for samp and beans). However, only 50% (20 out of 40) of the subjects correctly estimated the 700 g portion of samp and beans ($P<0,01$) in comparison to the 65% (22 out of 34) who correctly estimated the 700 g portion of stiff maize meal porridge ($P<0,01$).

As a further measure of the ability of subjects to estimate portion sizes, correlation coefficients were calculated between the estimated and actual weights for each food. The weakest correlation ($r=0,39$) was obtained for margarine spread on bread (Figure 4.6) and the strongest correlations were obtained for dumpling ($r=0,91$) (Figure 4.7), whole pilchards ($r=0,88$), apple ($r=0,86$), boerewors ($r=0,84$), fried beef ($r=0,81$) and meat stew ($r=0,81$). The correlation coefficients of all the other foods ranged between 0,6 (soft porridge) (Figure 4.8) and 0,8 (mashed pilchards).

All correlations were significant at $P<0,05$.

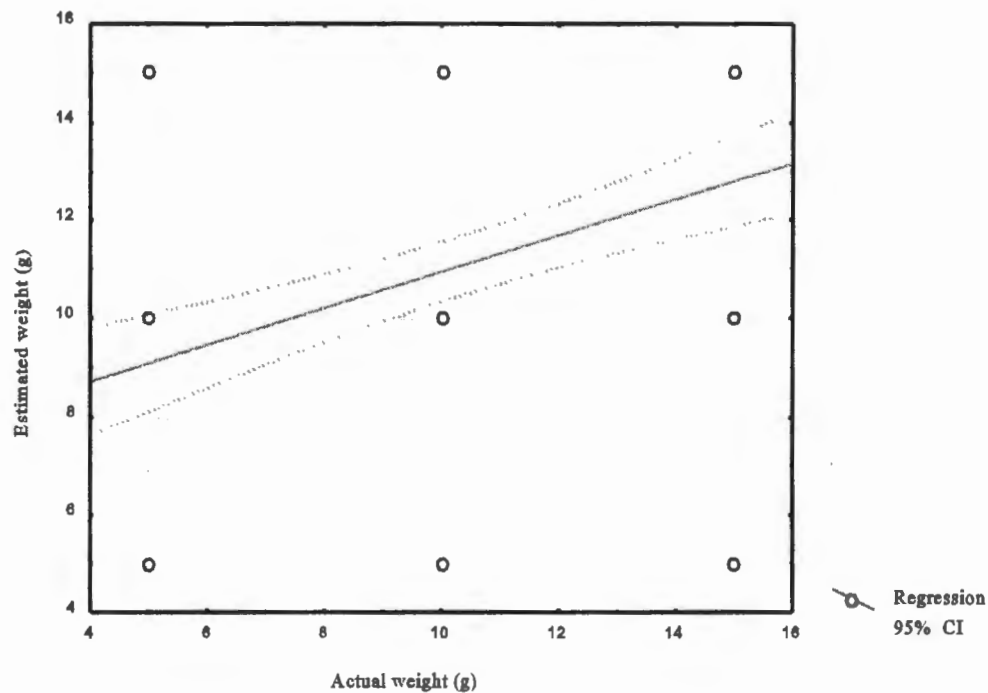


Figure 4.6: Scatter plot of estimated weight versus actual weight of margarine spread on bread (N=169)

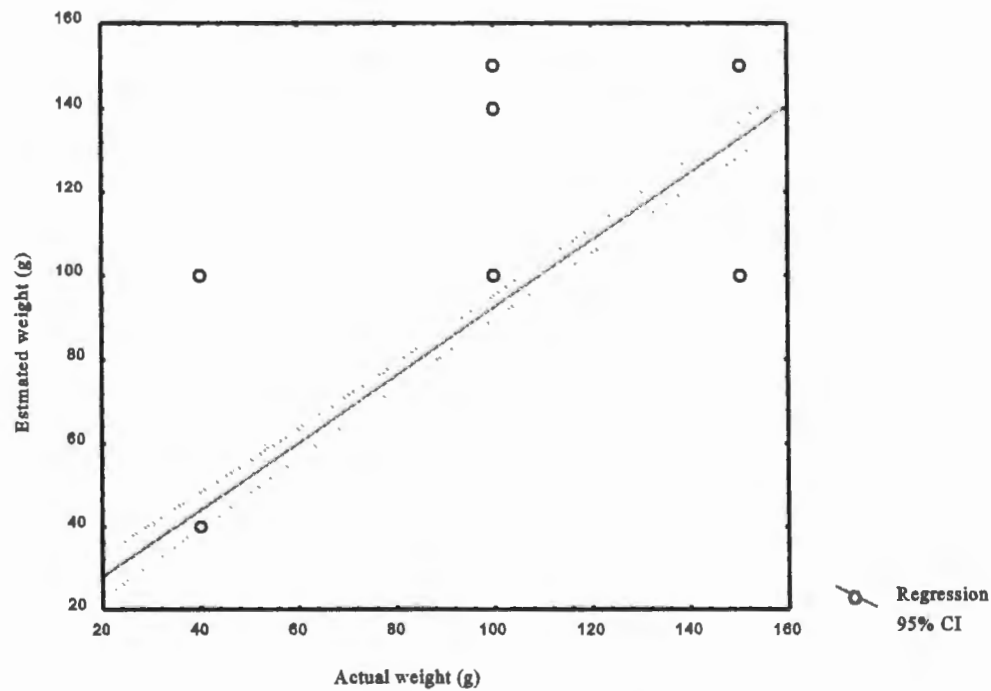


Figure 4.7: Scatter plot of estimated weight versus actual weight of dumpling (N=169)

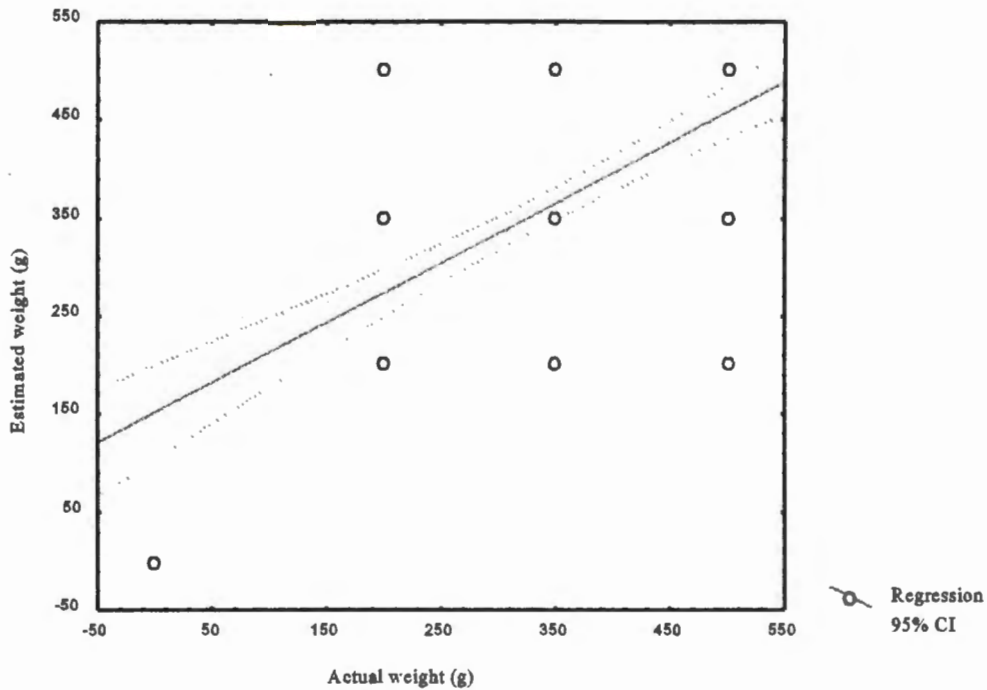


Figure 4.8: Scatter plot of estimated weight versus actual weight of soft porridge (N=169)

The finding that some foods were estimated more accurately than others was confirmed by a significant difference ($P=0,0$) between mean percentage differences in estimated and actual weights when the ANOVA (Statsoft, 1995) test was applied. To test the reliability of the testing procedure, the ratio of intra subject variation to inter subject variation was calculated (Dunn, 1989). A high ratio (0,91) was found, indicating that the test procedure was a reliable measure.

4.4.3 Degree of accuracy

The degree of accuracy was determined by the difference between the mean estimate and the true weight of the portion size expressed as a percentage of the true weight. The smaller the percentage difference the higher the degree of accuracy. Of all 62 portions, the mean estimates fell within 10% of the true weight for 27 (43,5%), and within 25% of the true weight for 49

(79%) of portions. The most accurate estimates (less than one per cent difference) were obtained for stiff maize meal porridge (large portion), bread (medium portion) and apple (medium portion) ($P>0,1$). The highest percentage errors were for the small portions of margarine spread on bread (86%) and beetroot (71%) ($P<0,0001$).

4.4.4 Individual subject responses

In an attempt to identify whether individual characteristics influenced the pattern of responses, the percentage of accurate, overestimated and underestimated responses was determined for each subject. The mean percentage of accurate responses was 67,8 % (SD=13,8%), of overestimations 15,5% (SD=11,7%) and of underestimations 16,9% (SD=10,4%).

4.4.4.1 Responses according to gender

When the responses of males and females were compared, there was no significant difference in the mean percentages of any of the categories (correct, overestimated, underestimated) ($P>0,05$) (Table 4.10). As can be seen from Tables 4.11 to 4.13, the pattern of correct, over- and underestimated responses was similar for both genders.

Table 4.10: Mean percentage correct, overestimated and underestimated responses for males and females (N=169)

Percentage	Males (N=39)		Females (N=130)		P- value	95 % *CI
	Mean	†SD	Mean	†SD		
Correct	65,0	14,3	68,7	13,7	NS	-47,2 -39,8
Overestimated	16,6	13,2	15,1	11,3	NS	- 2,74-5,74
Underestimated	18,7	10,6	16,4	10,4	NS	-1,47-6,07

† Standard deviation; *CI: confidence interval; NS: difference between means not significant $P>0,05$

Table 4.11: Frequency distribution of correct responses according to gender (N=169)

Percentage correct responses	Males (N=39)		Females (N=130)		Total (N=169)	
	N	%	N	%	N	%
0 - 20	0	0	0	0	0	0
21 - 40	2	5	6	5	8	5
41 - 60	8	21	34	26	42	25
61 - 80	22	56	71	55	93	55
81 - 100	7	18	19	15	26	15
Total	39	100	130	101	169	100

Table 4.12: Frequency distribution of overestimated responses according to gender (N=169)

Percentage overestimated responses	Males (N=30)		Females (N=130)		Total (N=169)	
	N	%	N	%	N	%
0 - 20	26	67	97	75	123	73
21 - 40	11	28	29	22	40	24
41 - 60	2	5	4	3	6	3
Total	39	100	130	100	169	100

Table 4.13: Frequency distribution of underestimated responses according to gender

Percentage underestimated responses	Males (N=39)		Females (N=130)		Total (169)	
	N	%	N	%	N	%
0 - 20	23	59	91	70	114	67
21 - 40	16	41	37	29	53	32
41 - 60	0	0	2	1	2	1
Total	39	100	130	100	169	100

4.4.4.2 Responses according to age groups

Although the sample was not stratified according to age groups, there were sufficient subjects in each age group to make comparisons meaningful (see Table 4.6). Subjects were divided into the same age categories as would be used in the dietary intake study. Figure 4.9 shows the mean and 95% confidence intervals of the percentage correct responses for each age group. The mean for the 45-54 year age group was the lowest (59%). However, when the differences between the

mean percentage of correct responses of the various age groups were tested using the Tukey test for honest significant differences (HSD), no significant differences were found among age groups ($P>0,05$).

When looking at the frequency distribution of correct responses (Table 4.14) the younger subjects appear to have a higher percentage of correct responses compared to the older subjects. Of the subjects in the age groups younger than 35 years, 75% (73) scored higher than 60 % correct, compared to 65% (45) in the age groups older than 35 years. No subject older than 55 years of age achieved more than 80% correct responses. However, these differences in percentages of correct responses did not reach statistical significance ($P>0,05$).

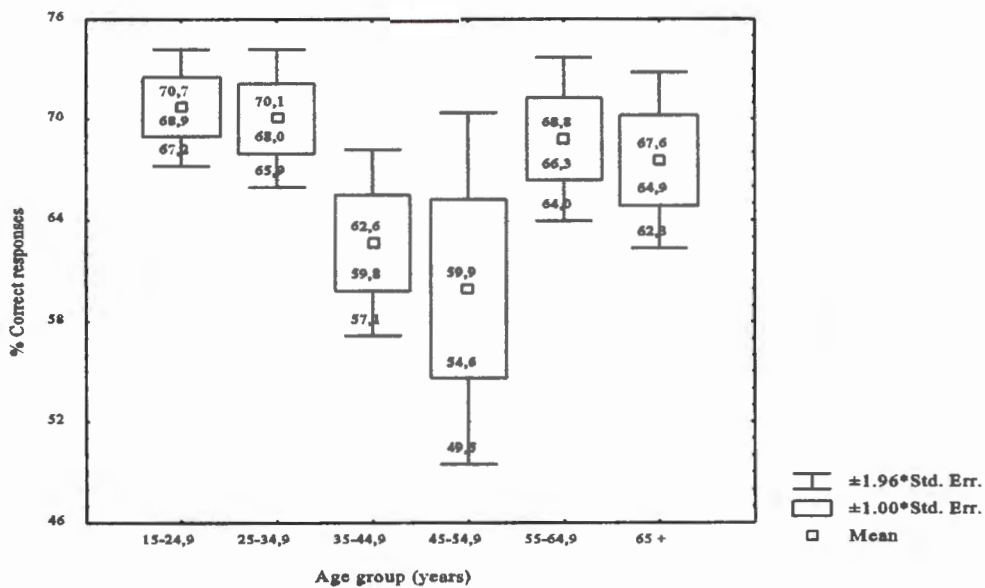


Figure 4.9: Means and 95% confidence intervals for percentage correct responses per age group (N=169)

Percentage responses	% correct		% overestimated		% underestimated	
	N	%	N	%	N	%
0 - 20	0	0	20	77	16	62
21 - 40	0	0	6	23	10	38
41 - 60	8	31	0	0	0	0
61 - 80	15	58	0	0	0	0
81 - 100	3	11	0	0	0	0
Total	26	100	26	100	26	100
Age: 65 - 74,9 years						
0 - 20	0	0	5	56	7	78
21 - 40	0	0	4	44	2	22
41 - 60	3	33	0	0	0	0
61 - 80	6	67	0	0	0	0
81 - 100	0	0	0	0	0	0
Total	9	100	9	100	9	100

4.4.4.3 Responses according to education level

As education might affect an individual’s ability to interpret a photograph, the percentage of correct responses for each level of education was compared. Similarly to age, post hoc analysis using the Tukey test for HSD showed no significant differences among education levels ($P>0,05$). Also, the differences among mean percentages for over and underestimations were not significant ($P>0,1$). As can be seen from Figure 4.10, the lowest percentage (61%) of correct responses was in the group with no education, while the highest variation occurred in the group with an education between grade 1 and standard 2 (48,3 to 82,7). The highest percentage of correct responses occurred in the group with a high school education (standards six to 10). Surprisingly, the mean percentage correct of the group with a post-school education was lower than those with a high school education (64% and 71% respectively).

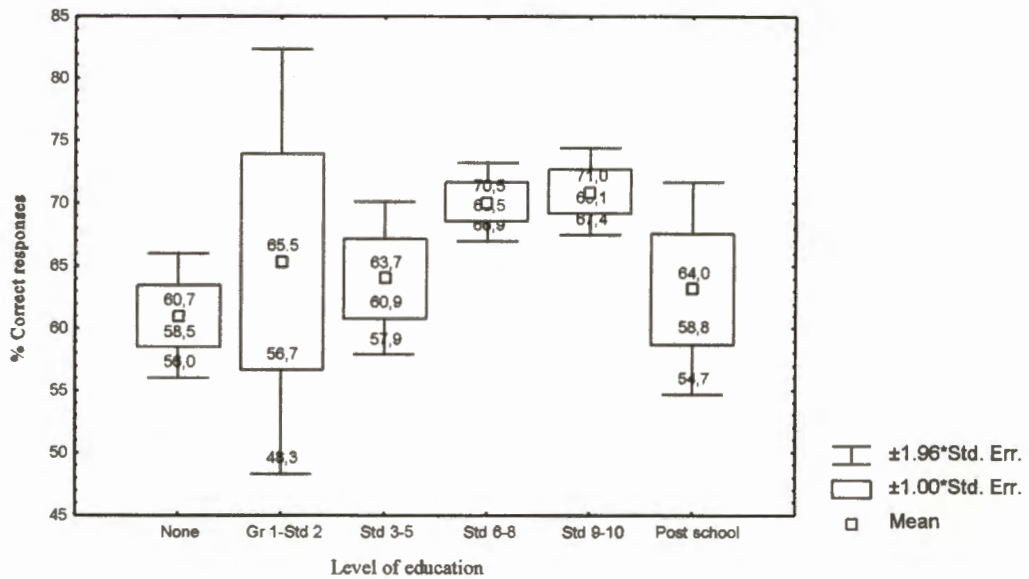


Figure 4.10: Means and 95% confidence intervals of percentage correct responses according to education level (N=169)

The distribution of the percentage of correct, overestimated and underestimated responses according to level of education is shown in Table 4.15.

Table 4.15: Percentage correct, overestimated and underestimated responses according to education level

Percentage responses	% correct		% overestimated		% underestimated	
	N	%	N	%	N	%
No schooling						
0 - 20	0	0	4	44	5	66
21 - 40	0	0	5	66	4	44
41 - 60	6	67	0	0	0	0
61 - 80	3	33	0	0	0	0
81 - 100	0	0	0	0	0	0
Total	9	100	9	100	9	100
Grade 1 to Standard 2						
0 - 20	0	0	4	67	3	50
21 - 40	1	17	1	16	3	50
41 - 60	0	0	1	16	0	0
61 - 80	4	66	0	0	0	0

Percentage responses	% correct		% overestimated		% underestimated	
	N	%	N	%	N	%
81 - 100	1	17	0	0	0	0
Total	6	100	6	100	6	100
Standard 3 to Standard 5						
0 - 20	0	0	15	60	16	64
21 - 40	4	16	9	36	8	32
41 - 60	5	20	1	4	1	4
61 - 80	16	64	0	0	0	0
81 - 100	0	0	0	0	0	0
Total	25	100	25	100	25	100
Standard 6 to Standard 8						
0 - 20	0	0	46	78	40	68
21 - 40	1	2	12	20	19	32
41 - 60	13	22	1	2	0	0
61 - 80	35	59	0	0	0	0
81 - 100	10	17	0	0	0	0
Total	59	100	59	100	59	100
Standard 9 to Standard 10						
0 - 20	0	0	43	81	42	79
21 - 40	2	4	8	15	11	21
41 - 60	13	24	2	4	0	0
61 - 80	30	57	0	0	0	0
81 - 100	8	15	0	0	0	0
Total	53	100	53	100	53	100
Post school						
0 - 20	0	0	11	65	8	47
21 - 40	2	12	5	29	8	47
41 - 60	4	23	1	6	1	6
61 - 80	9	53	0	0	0	0
81 - 100	2	12	0	0	0	0
Total	17	100	17	100	17	100

With regard to education level, it is notable that in all categories, other than that of no schooling, the majority of subjects estimated between 61 and 80 percent of the portion sizes accurately. Only subjects with a standard six education or higher estimated more than 80% of the foods accurately. There was no apparent trend of subjects to consistently over or underestimate portion sizes within each education level.

4.5 DISCUSSION

Although visual aids of some form are essential for assisting subjects to quantify their food intakes (Guthrie, 1984; Thompson & Byers, 1994), very little has been reported on the effectiveness and validity of these aids in the nutrition literature. As Cypel and co-workers (1997) have pointed out in a recent review article, there is a lack of research focussed on what they term 'portion-size measurement aids (PSMAs)'.

Several studies have illustrated that the use of photographs reduces estimation error (Guthrie, 1984; Pietinen *et al.*, 1988). However, little is known about the processes whereby people relate the amounts of food they eat as a portion, to a photograph of the food (Lucas *et al.*, 1995). Neither are there guidelines regarding the use of PSMAs to minimise estimation error, such as the optimum size and number of photographs, backgrounds and presentation (Cypel *et al.*, 1997). Nelson *et al.* (1994; 1996) identified three elements of the process which occurs when a photograph is used as an aid to portion estimation: perception, conceptualisation and memory. Perception is the subject's ability to relate the amount of food which is present in reality, to the amount depicted in a photograph. Conceptualisation is the subject's ability to develop a mental picture of a portion of food not actually present and to relate this picture to a photograph. Memory is the subject's ability to accurately recall the amount of food eaten and it will affect the accuracy of conceptualisation (Nelson *et al.*, 1994). The present study used the photographs of food portions to test the abilities of the subjects in the target population to compare actual food portions with photographs.

4.5.1 Pattern of responses

The percentages of correct responses (68%) and mean estimates within 10% of the actual weight (44%) obtained in the present study compare well with the results of similar studies to test the validity of food photographs. In the study by Lucas and co-workers (1995), of 3000 estimates, 49% were accurate and 70% fell within 10% of the actual value. In a study (Kirkcaldy-Hargreaves *et al.*, 1980) which compared different types of visual aids (food models, life-size colour pictures, abstract shapes and three-dimensional life-size black and white drawings based on the abstract shapes), an accurate response rate of 63% was obtained for life-size colour pictures. The similarity between the response rate obtained by Kirkcaldy-Hargreaves *et al.* (1980) and the present study was that both studies presented the pictures in colour and close to life size. It is also important to note that, while only 10% of the subjects in the present study (Table 4.7) had a post school education, the majority of subjects in the study of Kirkcaldy-Hargreaves *et al.* (1980) were students who had been exposed to Dietetics or Food courses.

In the present study, subjects tended to overestimate the small portion size and underestimate the large portion size. If they perceived the actual size as not matching the smallest portion, they had no option but to select the larger size. Likewise for the large portion, they could only select a smaller size, resulting in the so called 'flat-slope' phenomenon, that is, small sizes were overestimated and large sizes underestimated. Similar trends have been reported from the other studies (Faggiano *et al.*, 1992; Nelson *et al.*, 1994; Lucas *et al.*, 1995; Nelson *et al.*, 1996; Robinson *et al.*, 1997).

In the study by Lucas *et al.* (1995) subjects indicated when they thought that a portion size lay between the photographed portion sizes, or was smaller than the small size or larger than the large size. The result was that some (11 of the 45 foods) of the small portions were underestimated and two of the large portion sizes overestimated. However, few errors were made in the two extreme categories (smaller than the small portion and larger than the large portion) compared to errors made towards the medium portion sizes. Although the subjects in the present study were told that they could do so, only two subjects actually indicated that they thought a portion size lay between photographed sizes and no subject said that a portion lay outside the small or large sizes. The

reasons for this can only be postulated. It is possible that the subjects did not understand the instruction. As no subjects selected portion sizes outside the photographed range of sizes, it would seem that this was not the case. Rather, since the portion sizes were based on the usual sizes eaten by the study population, the photographed portions looked realistic so the subjects naturally selected one of the photographs. Another possibility could be that the subjects had difficulty in imagining portion sizes not actually pictured. Thus, they selected the photograph that appeared to them to be closest to the actual portion size.

Subjects in the study reported by Lucas *et al.* (1995) consistently overestimated or underestimated certain portion sizes. The authors ascribed this to specific factors relating to the visual perceptions of food portions in the photographs. For example, some of the real foods prepared for the tests differed in appearance to the photographed food. For example, given amount of food was sometimes presented in pieces that were either smaller and more numerous or larger and less numerous than those shown in the photographs. Since the portion sizes were overestimated in the first case and underestimated in the second, it appeared that the subjects' estimates were determined by the number of pieces. By contrast, in the present study, no consistent bias to over- or underestimate particular foods was detected. This may have been because the actual foods were prepared to resemble the photographed foods as closely as possible. Nevertheless, the appearance of some of the actual foods may have influenced the responses.

In the present study and the studies discussed above, perception, that is, the ability to match a portion size of food which is present in reality, to a photograph of the portion (Nelson *et al.*, 1994; 1996) was tested. In two recent studies (Nelson *et al.*, 1996; Robinson *et al.*, 1997), the ability to identify portion sizes from photographs when the food portion was not present (conceptualisation), was tested. In the study by Nelson and co-workers (1996), subjects (n=136) served themselves a meal of four to six foods. Each food serving was weighed. Within five minutes of having eaten the meal, subjects were shown photographs of eight portion sizes of the foods just eaten. The subjects indicated the size of the portion of food eaten on a visual analogue scale. Differences between actual and estimated weights varied between -28,4% (for baked beans served on a plate) to +249,2% (for margarine on crackers). The percentage of estimates within 10% of the actual weight varied from 12% (mashed potato) to 48% (quiche). When compared

to the results obtained for estimates of the same foods when perception only was tested (Nelson *et al.*, 1994), there was a slight decrease in proportion of correctly estimated portions (except for quiche). This difference, however, was only significant for boiled potato ($P=0,012$). Robinson and co-workers (1997) tested only two foods (mashed potatoes and corn flakes) by asking one group of subjects ($N=100$) to look at a served portion and then to estimate the portion size on a visual analogue scale from three portion size photographs without the actual food being present. A second group of subjects ($N=40$) was asked to serve themselves with a portion and then to estimate the portion size in a similar way. Differences between actual and estimated weights varied between -70,6% and 198,6% for served foods. The results from the self-served foods showed a smaller range of over and underestimation (-38% to +88%). The ability to conceptualise portion sizes of foods is extremely important as this was what subjects were asked to do when interviewed using the QFFQ in the dietary intake study. It can only be assumed that the ability to estimate portion sizes accurately in the present study would have declined had the subjects been tested in a similar manner to include conceptualisation.

As pointed out in the Results section, solid foods were more accurately estimated than amorphous foods. Similar findings have been reported by Weber *et al.* (1997), Howat *et al.* (1994) and Yuhas *et al.* (1989). These authors tested subjects' ability to estimate the weights of actual foods before and after training sessions. Amorphous foods such as apple sauce, beef stew, mayonnaise and spaghetti were less accurately estimated than solid foods. A possible explanation for this phenomenon is that amorphous foods do not hold their shapes and it is therefore difficult to find visual clues on the photograph to match with the actual food.

The poor response to the photograph of the tomato and onion sauce was possibly due to the amorphous nature of the food and the way in which it was photographed. Unlike all the other foods, it was photographed in an 8 cm x 10 cm x 3 cm transparent dish placed next to the 500 g portion of stiff maize meal porridge. Although most (89%) subjects were able to estimate the 20 g size accurately, they underestimated the 40 g and 80 g portion sizes. This might be due to difficulty in perception of depth and volume, as also found by Weber *et al.* (1997) and Lucas *et al.* (1995).

Other photographs where the perception of volume and surface area versus weight may have influenced estimation were of soft foods such as the pumpkin, spinach, mashed pilchards and beetroot. Transport and handling of the plates of these foods inevitably resulted in the spread of the food over the plate so that a larger surface area was covered. Subjects seemed to judge the surface area rather than weight and thus tended to overestimate the small and medium sizes. However, this was not a consistent trend. Cabbage, with a similar consistency and appearance to the foods just mentioned, was correctly estimated on the small size but underestimated on the medium and large sizes. Similar difficulty in judging depth and volume have also been found in other studies and ways in which to express volume and depth in food photographs must be investigated (Faggiano *et al.*, 1992; Nelson *et al.*, 1994; Lucas *et al.*, 1995, Young & Nestle, 1995).

The inaccurate estimation of amorphous foods was not a consistent finding for all such foods. For meat stew there was no significant difference between the actual weight and the mean estimated weight of the medium portion size ($P > 0.1$), while the differences between the mean estimates and the actual small and large portion sizes were less than 25%. All portion sizes were correctly estimated by 75% of the subjects. The reason for this difference in accuracy to other amorphous foods could be that the portion sizes of meat stew were considerably larger than for the other amorphous foods. Other studies have shown that larger portion sizes are more accurately estimated than smaller sizes (Gittelsohn *et al.*, 1994). In the study reported by Nelson and co-workers (1994), subjects used the width of the exposed area of the bowl of corn flakes as a clue to the amount of cereal in the bowl. A similar process may have occurred with the photograph of meat stew where a wide border of the plate was visible in the photograph of the small portion size, the border noticeably decreased in the medium portion size photograph and disappeared in the photograph of the large portion size.

The highest percentage difference of all foods and portion sizes was obtained for the five gramme portion of margarine spread on bread. This is understandable when the following factors are considered:

- (a) The three portion sizes for margarine were small (5 g, 10 g, 15 g) with only a five-gramme

difference between them. Therefore, differences would be difficult to detect and most subjects, if unsure, would select the medium portion. This is supported by other studies that have shown that small portions (less than 20 g) are less accurately estimated than larger portions (Gittelsohn *et al.*, 1994).

- (b) The slice of bread was covered with plastic wrap which could have distorted the appearance. However, the other two portions were also covered with plastic, yet were more accurately estimated.
- (c) The fact that subjects were actually seeing two foods (the bread and the spread) might have been confusing, even though the slice of bread in the photographs was the same weight and thickness for all three portions of margarine.

The difficulty in estimating spreads has been found by other workers. For instance, a high error rate was reported for butter on toast with a sample of young adults by Guthrie (1984) and in a sample of young women by Hunter *et al.* (1988). Nelson and co-workers (1996) found that portion sizes of butter and margarine were overestimated by 108% when shown spread on bread and by 243% when shown spread on crackers. Nelson *et al.* (1996) attributed this overestimation to the fact that the photographs showed butter in blocks with too few photographs of small quantities. They suggested that butter should be shown spread on bread as was done in the present study. An important fact which must be considered with regard to the spread in the present study is that the use of a spread such as margarine on bread is not a common practice among the study population. Thus, it is understandable that subjects had difficulty in estimating the portion size. The photograph of spread was included to cater for the urban, upper class stratum of the population, who follow a 'western' diet and who do use margarine or butter as spreads.

The photograph of fried beef was of a very well defined solid food. It was therefore surprising that the medium and large portion size photographs of fried beef were underestimated by 33% (18) and 36% (13) of the subjects respectively while the small portion size was overestimated by 9% (5). Some of the subjects appeared to be looking for visual clues when trying to match the

actual food to the photograph rather than matching the size. For example, they would turn their heads to look at the fried beef from different angles and seemed to be matching shape rather than size. Interestingly, subjects in the other studies of matching real foods to photographs also had difficulty in estimating pieces or slices of meat. In studies of Lucas and co-workers (1995) and Kirkcaldy-Hargreaves and co-workers (1980) subjects consistently overestimated fried beef steak and sliced meat respectively, while in the study of Nelson *et al.* (1994), sliced meat was underestimated. According to Faggiano *et al.* (1992) beef steak was among the foods for which substantial estimation errors were made. An explanation for the underestimation seen in the present study and that of Nelson *et al.* (1994) in comparison to the overestimation found by Lucas and co-workers (1995) could be related to the weights of the portion. In the former studies, all three portions were considerably smaller (30 g, 60 g, 100 g and 26-69 g, 70-139 g, 140-190 g respectively) than in the latter study (100 g, 130 g, 200 g).

A similar trend occurred with the small portion size of the whole pilchards. During the transport and handling, the small portion became flattened and more spread out than the photograph, so that it could have been two pieces of fish next to each other. Subjects seemed to match this with the large portion size photograph which depicted two pilchards close together.

In the studies reported by Nelson *et al.* (1994) and Lucas *et al.* (1995) foods were presented in random order to the subject, whereas in the present study, foods and photographs were presented to all the subjects in the same order, that is, the order in which they appeared in the food photograph picture book. This was done for two reasons: first, practically it would have been very time consuming and confusing to page back and forth in the book. Secondly, in the dietary intake study, photographs would be presented in the same order. If there was any learning or fatigue factor, it would also be present in the dietary intake study. Subjects in the study reported by Nelson *et al.* (1994), reported that they became more aware of factors which influenced their perception of portion sizes towards the end of the test session. However, there was no obvious learning or fatigue effect. Similarly, in the present study, no differences in accuracy of estimation could be ascribed to a learning or fatigue effect.

4.5.2 Degree of accuracy

The degree of accuracy found in the present study compares well with that of other studies. Mean estimates fell within 10% of the true weight for 44% of the food portions and within 25% for 79% of the foods, compared to 70% within 10% and 83% within 25% of the true value reported by Lucas *et al.* (1995). In the study by Nelson *et al.* (1994) subjects were asked to estimate the portion sizes of actual foods by comparison to either a series of eight photographs showing portion sizes graded from small to large or a single photograph of an average portion size. Between 59% and 73% of observations were within 20% of the true value using the series of eight photographs. The percentage of responses within 20% of the true value using the single average photograph varied between 23% and 64%. The advantage of using food photographs as an aid to portion size estimation is clear when the results of the present study are compared to those of Guthrie (1984) who measured the accuracy of estimation without PSMA's. Guthrie (1984) reported estimates within 25% of the true value by between 8% (for butter on toast) and 73% (for orange juice) of 147 subjects asked to describe, without the help of PSMA's, the types and amounts of foods consumed at a controlled meal.

4.5.3 Characteristics of the subjects

4.5.3.1 Gender

Since women are usually responsible for the purchase, preparation and serving of food, it might be expected that they would estimate food portion sizes more accurately than men. There is little evidence from the literature that this is the case. Most studies that have examined portion size estimation using photographs, or other methods, have used female subjects only (Clapp *et al.*, 1991; Kuehneman, 1994; Lucas *et al.*, 1995; Weber *et al.*, 1997) or, in two cases, males only (Pietinen *et al.*, 1988; Rapp *et al.*, 1986). Of those that have used both genders some have not compared the accuracy of estimation (Bird & Elwood, 1983; Kirkcaldy-Hargreaves *et al.*, 1980). The results of studies that have compared the degree of accuracy of estimation of males and females are contradictory. Some studies have reported gender differences, while others have not. Yuhas *et al.* (1989) reported that women were more accurate in estimating portion sizes than

men. Nelson *et al.* (1994) found that males tended to underestimate while females tended to overestimate portion sizes. The mean percentage of underestimated responses of the males (1.4%) was less than that of overestimation of the females (2.8%) when the series of eight portion sizes was presented. However, men made more errors than women when the average portion size photograph was used. In their second study, Nelson *et al.* (1996) reported that men tended to overestimate portion sizes more frequently than women. In the study by Posner *et al.* (1992), where the accuracy of portion size estimation using three-dimensional food models was compared with that using a two-dimensional food model chart, the percentage of female subjects within 20% agreement ranged from 69% to 100%, while for males it varied between 70% and 94%. In contrast, Faggiano *et al.* (1992) and Robinson *et al.* (1997) have reported that there was no difference between the accuracy of estimation of portion sizes by males and females.

There was no significant difference in the present study between the percentage of correct estimations of males and females, neither was there any apparent trend of one gender to overestimate nor underestimate portion sizes. The difference in sample sizes (39 males and 130 females) may have contributed to this finding. Clearly, more research is needed into the effect of gender on portion size estimation, and as pointed out by Young and Nestle (1995), men and women with similar experience in food handling need to be compared in order to determine whether gender plays a significant role in portion size estimation ability.

4.5.3.2 Age

Although age might be expected to affect the accuracy of portion size estimations, in the present study, the differences in the percentages of correct, over- and underestimated responses between age groups were not statistically significant.

One factor which goes together with age and which may affect the accuracy of estimation of food portion sizes from photographs is the deterioration of eyesight with age. A few of the older subjects seemed to have difficulty in seeing the photographs and had to bend over the book. However, all three elderly subjects with apparent difficulty in seeing estimated more than 13 out of the 20 photographs correctly. Moreover, there was no statistically significant difference

between the percentage of accurate responses in the over 55 year age groups and the younger age groups. To add to the difficulty in interpreting the effect of age and vision on estimation, one younger subject (45 years old) who also appeared to have difficulty in seeing only estimated five photographs correctly.

There is little in the literature with which to compare these results. In the first study reported by Nelson and co-workers (1994), the age group older than 65 years tended to overestimate portion sizes when shown the eight portion size photographs and to underestimate the average portion size less frequently than the other age groups. When the ability to conceptualise portion sizes was tested, Nelson *et al.* (1996) reported that subjects older than 65 years of age overestimated portion sizes more frequently than younger subjects while Robinson and co-workers (1997) found no differences in accuracy of estimation between age groups. No other published studies have specifically looked at the effect of age on the ability to estimate portion size from photographs, although difficulties in reporting portion sizes, with or without visual aids, have been reported for all age groups (Young & Nestle, 1995). Zegman (1984) and Faggiano *et al.* (1992) have reported no effect of age on food portion estimation.

4.5.3.3 Education level

The ability to interpret a photograph of a food may be explained by what has been termed 'pictorial literacy' (Fuglesang, 1973). People have to learn to read pictures just as they have to learn to read written words. The development of pictorial literacy, however, is a more informal process and occurs naturally in environments where pictures of all kinds are an integral part of the individual's environment. In environments where there are no, or very few pictures, such as a remote rural area, this process cannot occur. Although the development of pictorial literacy can occur independently of the development of literacy itself, literacy and thus education level nevertheless is an important factor in determining the ability to interpret pictures (Fuglesang, 1973). Taking this factor into consideration, a limitation of the present study could have been that no subjects from rural or farm areas were tested. Such individuals might not have been exposed to as pictorial an environment as individuals from the informal settlement and urban areas, and thus not have been as pictorially literate. Thus, a lower level of accuracy might have been

obtained.

It could be expected that subjects with little or no education might not be able to estimate portion sizes using food photographs as accurately as those with a higher education level. However, in the present study, the mean percentage correct estimations of the subjects with no education, or education less than standard five, did not differ significantly from that of those with a high school education ($P>0,05$). Interestingly, the accuracy of estimation did not improve with higher education after standard six ($P>0,05$). As with age, there were no statistically significant differences in the percentages over- and underestimated by the various levels of education ($P>0.1$).

No other studies have looked at the role of education in the interpretation of food photographs. Kirkcaldy-Hargreaves *et al.* (1980) compared the accuracy of responses of subjects with different levels of exposure to food models, but only found significant differences between responses for five out of 43 foods (peas, dry cereal, peanuts, chops, butter). A possible comparable study could be that of Nelson *et al.* (1994) who looked at differences among occupation groups. There were no obvious differences in performance among the non-manual, manual and non-working or unemployed groups, while being retired was associated with overestimation, an effect which disappeared when age was considered. From these results, it seems that education or occupation levels have little influence on portion size estimation. Another comparable factor to education is income level. Webb and Yuhas (1988) reported that subjects enrolled in a food assistance programme overestimated portion sizes. However, as these results were not compared to a higher level income group, the results are inconclusive.

4.5.3.4 Body weight

Although body weight was not recorded in this study, the possible effect of body weight on portion size estimation must be discussed. It is well known that overweight and obese subjects tend to underestimate their food intake (Bandini *et al.*, 1990; de Vries *et al.*, 1994; Hulshof *et al.*, 1995) while underweight subjects overestimate their portion sizes (Yellowlees *et al.*, 1988).

In the study by Nelson *et al.* (1994) subjects with a body mass index (BMI) greater than 30 kg/m² underestimated portion sizes compared to the other subjects when eight photographs were used, but not when the single average portion size photograph was presented. Fat was found to be significantly underestimated by subjects with BMI over 30 kg/m² and the energy and fat content of meals was lower than in the group with BMI less than 25 kg/m² (Nelson *et al.*, 1996). These authors suggest that, as heavier subjects eat larger portions, they are likely to underreport the amounts. In contrast, they found that subjects with a BMI of less than 25 kg/m² underestimated portion size similarly to the heavier subjects when the average portion size was presented, but not with the eight portion size photographs.

In contrast to the results reported by Nelson *et al.* (1994), Zegman (1984) found that obese subjects estimating portion sizes using food models overestimated quantities more frequently than they underestimated quantities (37% overestimated compared to 16% underestimated). There was no correlation between the percentage overweight and the percentage of correct estimations (Zegman, 1984). Likewise, in comparing the accuracy of estimation of portion sizes of actual foods by obese compared to normal weight female subjects, Blake and co-workers (1989) found that the mean estimations of the overweight subjects were more accurate than those of the normal weight subjects for two of 10 displayed food. There were no significant differences between mean responses for eight of the foods. In addition, there was a tendency for obese subjects to overestimate portion sizes to a larger extent than the normal weight subjects.

A shortcoming of this study to test the food portion photographs was the failure to record body weight and height and to calculate BMI. As can be seen from the above discussion, it cannot be assumed that overweight subjects will underestimate portion sizes. The comparison of the accuracy of portion size estimations of subjects with different BMI's could have shown whether accuracy and BMI were related in any way. This information could have been used in the interpretation of the results of the dietary intake study, where BMI was measured.

4.5.4 The size, colour and number of food portion photographs

When comparing the degree of accuracy of food portion size estimation reported by various

authors, differences in photograph size must be born in mind. In most reported studies the food photographs have been reduced in size. By contrast, in the present study they were enlarged (21x29,5 cm). Nelson *et al.* (1994) tested photographs of different sizes (150x200 mm, 100x150 mm and 75x100 mm), Lucas *et al.* (1995) reduced their photographs to 188 mm x 60 mm, while Pietinen *et al.* (1988) used some life-size and some reduced scale photographs. The only other study to use life-size pictures was that of Kirkcaldy-Hargreaves *et al.* (1980) who obtained a 63% accuracy rate. Posner *et al.* (1992), who compared the accuracy of estimation of three-dimensional models with two-dimensional pictures, found that the proportion of subjects whose estimates were within 20% agreement for the two methods ranged between 0,69 and 1,00. Nelson *et al.* (1994), however, found no significant differences in the degree of accuracy among photograph sizes, but recommended that 75 x 100 mm be the minimum acceptable size for food photographs.

These are the advantages of using near life-size photographs:

- (a) The appearance of the food is very close to that of the real foods. The texture can be seen and the different types of foods in mixed dishes can be distinguished. For instance, subjects were able to distinguish between the meat and vegetables in the meat stew and between the cabbage and potato in the cabbage photograph and the tomato and onion sauce clearly contained both tomato and onions. This meant that subjects could relate to the foods and easily recognised them for what they were.
- (b) Subjects did not have to mentally increase the size of the photographs to the actual size in order to make the comparison between photograph and real food, which may have led to mistakes in their estimations. Important parts of visual perception are the 'constancy phenomena' including colour, shape and size constancy (Fugleson, 1973). By keeping the size, shape and colour as close to the real thing as possible, visual perception is improved.
- (c) The size of the plate looked real, making it unnecessary to have some utensil such as a knife or fork or scale bar (Pietinen *et al.*, 1988; Lucas *et al.*, 1995) to represent actual size.

The only disadvantages of using near life-size photographs were of a logistic nature. The food portion photograph books were large and heavy and therefore more difficult transport and use than would a book with smaller photographs have been. The cost of compiling a large book was also high. Nevertheless, the probability of obtaining more accurate results using near life-size photographs far outweighs the disadvantages.

With regard to colour, Nelson *et al.* (1994) compared the responses to black-and-white photographs with the responses to colour photographs. The mean percentage difference of the estimated from the actual weight was slightly (but not significantly) higher for the colour photographs (2%) for both the eight portion sizes as well as the average portion size. Colour photographs were associated with slight overestimation of the eight portion sizes and underestimation of the average portion size. In comparing colour pictures to black-and-white free hand drawings, Kirkcaldy-Hargreaves *et al.* (1980) found little difference in the accuracy of responses (62,8% for colour pictures and 60,5% for black-and-white drawings). However, it is not clear whether this difference was due to the colour, or the type of picture, or a combination of these factors. It is therefore difficult to draw any definite conclusions regarding colour. Black-and-white photographs are less expensive to produce. However, printing rather than photocopying, (Nelson *et al.*, 1994) is necessary for clear reproductions and this increases the cost. Colour photographs have the advantage of being more attractive and may help to keep the subject's attention during long interviews (Nelson *et al.*, 1994). They are also more realistic and fulfil the criterion of colour constancy (Fuglesang, 1973). Thus, colour photographs do not require the subject to imagine the colour of the food before comparing it to the actual portion. A note of caution must be expressed regarding the use of colour photographs, however. It is extremely important that colours are realistic. As was seen with the first tests using the trial photographs, subjects found inaccurate colours confusing. This may distract subjects from concentrating on the amount of the portion. Thus, experimenting with lighting and backgrounds as well as with reproduction is essential for realistic colour photographs to be produced.

There are no clear guidelines in the literature as to the number of portion sizes of each food to be presented to the subjects. Some studies have used the same number of portions for each food (Faggiario *et al.*, 1992; Lucas *et al.*, 1995; Fidanza *et al.*, 1995) while others have used different

numbers of portion sizes for different foods (Pietenin *et al.*, 1988). Only Nelson and co-workers (1994) compared the degree of accuracy of reporting with the number of photographs presented. These workers presented subjects with actual foods to compare with either a single average portion size photograph or a series of eight photographs graded from small to large. They found that the use of a single portion size photograph was associated with larger errors of estimation than the use of the series of eight photographs, particularly with regard to underestimation of large portions.

In the present study, three portion sizes were presented for all foods, except the stiff maize meal porridge and the samp and beans. An extra large portion size (700 g) was included for these foods to cover the very large amounts consumed by men in some areas. For both these foods, the large size (500 g) was accurately estimated, while the medium and small sizes were overestimated and the extra large size underestimated. Particularly, subjects selected the large (500 g) photograph instead of the medium photograph (250 g or 150 g). It is not clear whether the extra portion size made any difference to the subjects' ability to accurately estimate them.

4.5.5 Implications for the dietary intake study

The purpose of the study was to test the use of the food portion photograph book as an aid for portion size estimation for the dietary intake study. Some important points came out of the study regarding the food portion photographs.

In any study on dietary intakes, it is essential that the staple foods of the diet be accurately estimated. Due to the frequent consumption of these foods by the population, small errors in the estimation (either over- or underestimation) could lead to a distorted picture of food, energy and nutrient intakes of the population. The most frequently consumed food by the majority of the African population of the North West Province is stiff maize meal porridge. It is therefore reassuring to note that 63% of the subjects were able to estimate it correctly and that the percentage of error for all portion sizes was less than 25%. Also important is that the large 500 g portion size was the only portion with no difference between the mean estimated weight and the actual weight. The samp and bean mixture is also a dish that is frequently

consumed. Although a lower percentage of accurate estimations (56%) was made than for stiff maize meal porridge, the large (500 g) portion size was also accurately estimated. The foods which were the least accurately estimated (such as beetroot, pumpkin, tomato and onion sauce, and margarine, all of which had percentage errors greater than 50%) are foods that are either eaten in small amounts as relishes (for example, tomato and onion sauce), or these foods are eaten in small amounts and infrequently. For example, beetroot salad and pumpkin are generally only eaten on Sundays and margarine is used as a spread occasionally. This might also have been the reason for the poor estimation of these portions as these foods were not as familiar as the other frequently consumed foods. A similar conclusion has been drawn by Gittelsohn *et al.* (1994) who reported that amounts of commonly eaten foods were more accurately estimated by observation than amounts of less frequently eaten foods.

It must be remembered that, while the study was conducted under fairly controlled conditions, it was done under field conditions similar to those of the actual dietary intake interviews. Subjects were presented with the actual foods that were as similar to the photographs in appearance as possible. The subjects thus did not have to remember the portion sizes they eat, or to conceptualise an 'average' or 'usual' portion size and then try to relate it to the photographs. They also did not have to mentally compare the type of plate on which their food is served to that of the different type of plate in the photograph. Possibly, the study might have produced more valid results had different types of plates been used and had the foods not been prepared to be as close in appearance to the photographed foods. Food portion photographs have also been tested in other settings with good results. Friel *et al.* (1995) described the validation of food portion photographs by asking subjects to keep a three-day weighed food record and at the same time to quantify amounts by selecting a photograph best representing the food portion. No significant differences were found between the mean weighed intakes and the mean weight estimated by the photographs.

There is also a question as to how accurately the food photographs can be used to estimate a recalled intake. In a study by Robson & Livingstone (1995), 30 adult subjects ate three meals (breakfast, lunch and dinner) in a metabolic unit on two non-consecutive days. On the following day, subjects were asked to estimate the amounts of all foods which they had eaten in terms of

fractions, or multiples of the amounts shown in single-portion-size colour photographs. At group level for both days, 17 foods were overestimated and 16 underestimated. (The authors do not specify the total number of foods tested). When the nutrient contents of the weighed and the estimated recalled intakes were compared, more than 60% of subjects fell into the same tertile for all nutrients examined. The authors conclude that food photographs may be useful in ranking subjects according to nutrient intake in recall situations.

4.6. RECOMMENDATIONS AND CONCLUSIONS

The aim of this part of the study was to develop and validate a set of visual aids in the form of a food portion photograph book to be used with the QFFQ designed for the study on the dietary intakes of the African population of the North West province. By using the information gained in the preliminary study and by pretesting the food photographs, a food portion photograph book was constructed appropriate to the types and amounts of foods consumed by the target population.

To test the validity of the food portion photograph book, the null hypothesis that there would be no difference between the estimated mean weight of each portion size of each food and the true weight of that portion size was tested. The null hypothesis was not rejected for 20 out of the 62 portions tested ($P > 0,05$). Of all the portion sizes tested (2959), 69% were correctly estimated by the subjects. Mean estimated weights fell within 25% of the true weight for 79% (49) of the food portions tested.

Since an individual's characteristics might affect the way in which they perceive the food portion photographs, the null hypotheses that there would be no differences in the level of accuracy of estimation between males and females and among age groups or education levels were tested. With all three variables, the null hypotheses were not rejected. In other words, gender, age and education level did not appear to influence the accuracy of portion size estimation. Nevertheless, these are important factors to consider when conducting dietary intake studies and interpreting the results. The testing of the food portion photograph book under controlled laboratory conditions is recommended to identify individual characteristics which could influence portion

size estimation.

In view of the fact that those foods most frequently consumed (stiff maize meal porridge, samp and beans, bread and meat stew) were generally well estimated and foods which make a relatively small contribution to the diet of the African population of the North West province (such as margarine, beetroot, tomato and onion sauce) were poorly estimated, it may be concluded that the food portion photograph book was an appropriate aid to the estimation of portion sizes and that the subjects were able to relate actual foods to the photographs. However, in drawing these conclusions, the following limitations must be born in mind:

- (a) Although the sample was drawn from informal settlement and middle-class urban areas of the North West province, similar to those used in the food intake study, it did not include subjects from rural and farm areas. Different results may have been obtained had these subjects been included, as their education levels and exposure to pictorial stimuli might be lower than that of subjects in urban areas.
- (b) The number of women in the sample was much greater than that of men (130 and 39 respectively), which would have biased the sample in favour of women. Since women are responsible for the preparation and serving of meals, they might have a better ability to estimate portion sizes than men.
- (c) The actual foods were prepared and presented to resemble the photographed foods as closely as possible. This could have made it easier for subjects to recognise the portion sizes. As pointed out by Lucas *et al.* (1995) subjects do not all use the same types of plates and in reality no two servings of food can look exactly the same. Thus, it might have been more valid to have kept the weights of the portion sizes of the actual food the same as the weights of the photographed portions but to have varied their appearance.
- (d) The subjects' ability to recall and conceptualise foods and amounts eaten was not tested at all in this study, but only their ability to estimate the amount of a given actual food with a photograph of the portion size.

The following recommendations are made to improve the effectiveness of the use of the food portion photograph book:

- (a) The food portion photograph book will need to be revised after completion of the food intake study, to determine which foods and portion sizes are indeed the most frequently used by the African population of the North West province.
- (b) Differences in portion sizes should be made more obvious by exploring ways of photographing foods to create a sense of depth and volume.
- (c) In the present study, the food portion photograph book was tested under field conditions which made the detection of factors which could influence estimation difficult. The photographs should be tested under controlled conditions to identify characteristics, both of the foods and of the subjects, which influence portion size estimation.
- (d) Information needs to be obtained on how subjects perceive the food portion photographs. As discussed by Cypel *et al.* (1997) this should involve collaboration with cognitive psychologists to identify where difficulties arise in the use of the photographs and how they should be employed in dietary intake interviews to achieve the most accurate portion size estimates. Different ways of using the photographs could also be investigated. For example, Kumanyika and co-workers (1996) asked subjects to sort picture cards of foods into groups of foods according to the frequency of consumption, prior to the interview. The interviewer started the interview by asking about the foods most frequently consumed.
- (e) The effect of conceptualisation on the accuracy of portion size estimation needs to be evaluated in a similar way to the studies of Nelson *et al.* (1996) and Robinson *et al.* (1997).
- (f) As done in a number of studies (Kirkcaldy-Hargreaves *et al.*, 1980; Posner *et al.*, 1992; Kuehneman *et al.*, 1994) and recommended by Young & Nestle (1995), the use of the

food portion photograph book needs to be compared with other PSMA's, such as food models, abstract shapes and pictures, to determine which PSMA's give the most accurate estimations.

With regard to the use of the food portion photograph book for the dietary intake study, it was concluded that the book would be a useful aid to the estimation of portion sizes. Nevertheless, the shortcomings discussed above will have to be taken into consideration in the interpretation of the data. Also, before the book can be used for other studies, the results of the dietary intake study itself, such as the frequency of food and portion size consumption will have to be checked and used to modify the food portion photograph book.

CHAPTER 5

METHODS: DIETARY INTAKE STUDY

5.1 SUMMARY

The dietary intake study formed a part of the larger THUSA study. This chapter describes the development and testing of the dietary intake interview schedule, the recruitment and training of the field workers and the procedures used for the collection of the dietary data. In addition the methods used for the selection of the sample for the THUSA study, the procedures followed to establish contact in the study areas, the recruitment of the subjects and the procedures followed for the THUSA study as a whole are described.

5.2 INTRODUCTION

As outlined in Chapter 1, the dietary intake study comprised three substudies: the reproducibility study, the relative validation study and the application of the QFFQ to determine the effects of urbanisation on dietary intakes. The dietary intake study formed part of the larger THUSA study. The reproducibility and relative validation studies for the QFFQ were carried out concurrently to the main dietary intake study. The design of the THUSA study is shown schematically in Figure 5.1.

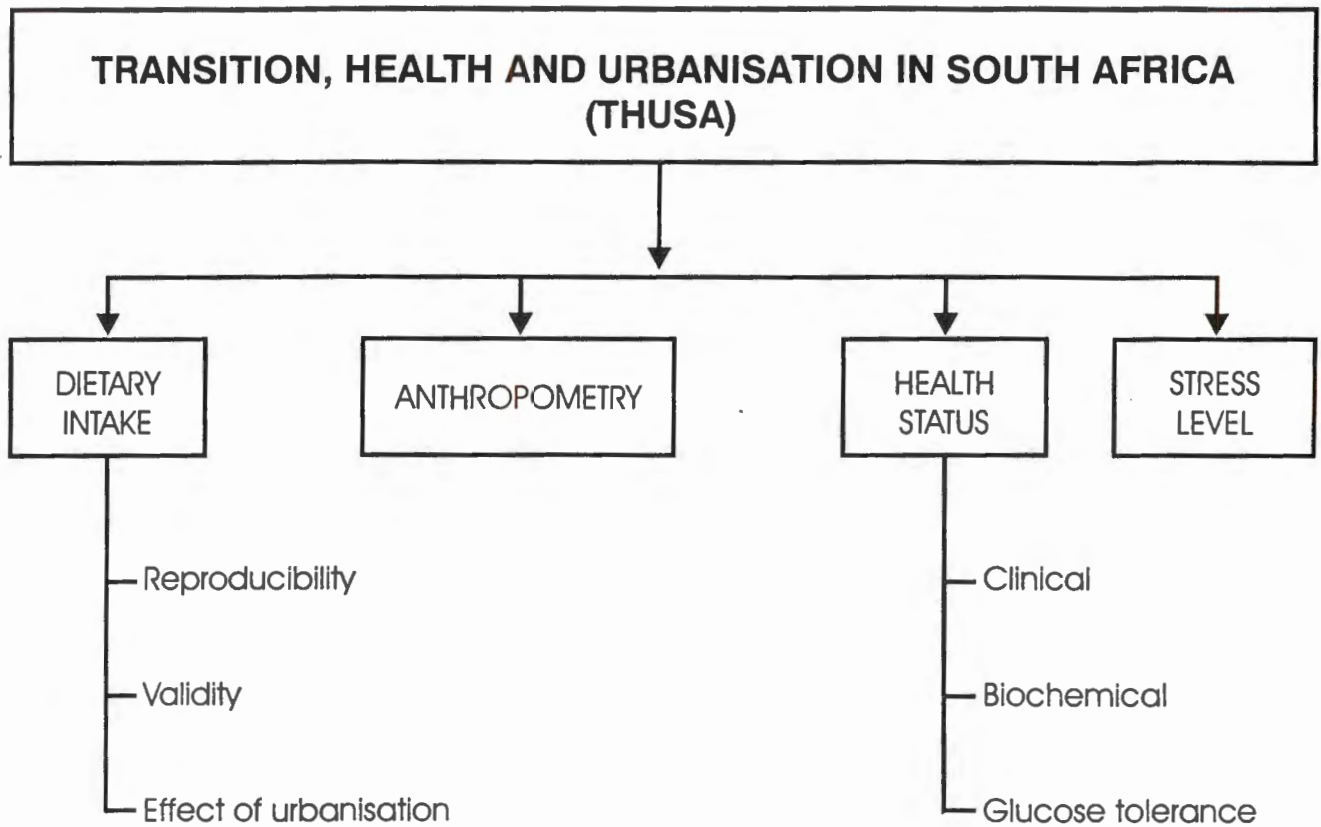


Figure 5.1: Schematic representation of the design of the THUSA study

This chapter describes the methods common to the three substudies, that is, the development of the interview schedule (IS), the recruitment and training of the field workers, sample selection of the THUSA study, the data collection procedures of the THUSA study and data collection using the IS. The methods used specifically for the collection of data for the reproducibility study and the validation study will be described in Chapters 6 and 7 respectively.

5.3 DEVELOPMENT OF THE INTERVIEW SCHEDULE

The information collected during the preliminary study (Chapter 3) was used to develop the IS for use in the reproducibility and validity studies as well as the dietary intake study. The IS (Appendix F) consisted of three parts:

- (a) Questions relating to the degree of acculturation
- (b) Questions regarding meal patterns
- (c) The quantitative food frequency questionnaire (QFFQ).

The development of each of the above parts of the IS is described below.

5.3.1 (a) Acculturation

Since the primary aim of the THUSA study was to describe the effects of urbanisation on the health status of the population of the North West province, it was necessary to collect information concerning the rural-urban flow of the sample. The purpose of the questions in the first part of the IS was to establish the length of time the respondents had lived in the present area, if not born in that area, what type of area (rural, farm, informal settlement, middle class urban or upper class urban) they had lived in previously and the extent of contact across strata of urbanisation. These questions had been included in the IS for the preliminary study (Appendix A). The modifications mentioned in Chapter 3 were made before inclusion in the final IS.

Question 1 was modified from the preliminary study to first ask about the place of birth and then to establish the length of time lived in the present area. The response categories to Question 1.1 (How long have you lived in this area?) were made more specific and the number increased. For example, instead of 'came as a child', options were stated in terms of years from 'less than one' to 'more than 20 years'.

Question 2 was included to find out whether the subject had moved across levels of acculturation. In the preliminary study, it was found that merely asking where the respondent had lived before did not provide adequate information. It was not always clear from the name of the area whether it was a farm, rural, informal or middle class urban area. Therefore, question 2.2 was added to ascertain the type of area.

Questions 3 and 4 were included in an attempt to ascertain the movement of respondents across strata of urbanisation by asking about visits to relatives living in other areas. From the preliminary study, it was apparent that there was movement both from the rural and farm areas to the urban

areas and from the urban areas to the rural and farm areas. Thus, urban respondents were asked question 3, regarding contact with rural and/or farm areas and rural and farm respondents were asked question 4, regarding contact with urban areas. As respondents find recall easier if questions refer to a specific time period (Feuerstein, 1986; Bailey, 1987) , and Christmas is a memorable time, the time period 'from Christmas to Christmas' was added to questions 3.3 and 4.3.

The section on acculturation was made the first part of the IS as the questions are straight forward and easy to answer. Thus, the subject would gain confidence to continue to answer the rest of the IS (Feuerstein. 1986, Bailey, 1987, Judd *et al.*, 1991).

5.3.2 (b) Food habits

As a QFFQ determines only the frequency of food consumption, a separate section was included in the IS to ascertain the meal patterns of the respondents. This information was necessary to determine whether the meal pattern changed across strata of urbanisation. The format of these questions was to ask about the meals eaten the previous day, as respondents could be expected to remember this information accurately (Bailey, 1987). Respondents were then asked whether this pattern was similar to most days. This differentiation was necessary, since as was seen in the preliminary study, the meal pattern of week days may differ from that of the week end. Questions were also asked concerning the consumption of food or drinks between meals (snacks) (Question 3) Question 4 (how is food served at most meals in your family?) was included to find out who was responsible for the division of food between family members and whether the pattern of food service was influenced by the degree of acculturation. Question 5 was asked to determine the frequency of meals eaten away from home.

5.3.3 (c) The quantitative food frequency questionnaire (QFFQ)

The QFFQ made up the largest portion of the IS. The QFFQ was based on that validated by Vorster *et al.* (1985) and used in other dietary intake surveys undertaken by the PU for CHE (Gresse, 1991; Mia, 1992) but was adapted according to the findings of the preliminary study. Food items with their description were listed on the left side of the page. The descriptions of the

food preparation methods were obtained from the results of the preliminary study. The recipes obtained from the participants in the preliminary study were coded and entered into the dietary analysis program for use in the analyses. Columns were provided for the amount eaten and the frequency of consumption (number of times per day, per week, per month or seldom). The last two columns provided space for the food code and the calculated amount of the food consumed per day.

Foods that are similar or are eaten together were grouped together, rather than using traditional 'food groups' classification. This was done as the respondents do not think in 'food groups' but associate foods with meals or with other foods (Smith-Barbaro *et al.*, 1982; Wheeler *et al.*, 1994). An attempt was also made to reduce the monotony of answering food frequency questionnaires and to avoid the development of a response set by changing the format of some questions.

The first questions asked about the consumption of maize meal for the following reasons:

- (a) Maize meal is the staple food of the population of the North West province and is frequently eaten in large amounts. Thus, respondents should find questions relating to maize meal easy to answer. The respondents would then feel more comfortable with the interviewer and encouraged to continue with the interview (Bailey, 1987).
- (b) Maize meal provided the bulk of the energy intake of the population. Thus, as accurate information as possible must be obtained. More accurate responses can be expected early in the interview before the respondent loses interest or becomes tired. (Bailey, 1987).
- (c) Although it was found in the preliminary study that the upper class urban participants tended to eat less maize meal than other participants, these participants represented only 20% of the total sample and most did include maize meal at least on a weekly basis in their diets.

As some commercial maize meals are enriched with vitamins, the brand name was asked so that the correct code could be used for the analyses. Respondents are more likely to be able to answer a question referring to products they use at present rather than products 'usually' used

(Judd *et al.*, 1991). Male respondents or respondents who are not responsible for food preparation might not have been able to answer questions regarding food procurement and preparation. Therefore, 'Don't know' options were provided for all applicable questions (Bailey, 1987).

Chicken was found to be the most frequently eaten form of meat in the preliminary study and was therefore the first food to be mentioned in this group. Likewise, the most commonly consumed foods in the other food groups (apples and cabbage in the case of fruit and vegetables respectively) were asked before other related foods.

Questions regarding the procurement of food (such as maize meal, chicken, red meat, fruit and vegetables) were included in the QFFQ to ascertain food procurement practices. These questions were placed in the body of the QFFQ, rather than in a separate section for the following reasons:

- (a) The questions provided an introduction to the asking about foods in that particular group.
- (b) A change in the question style provides a break in the monotony of the QFFQ and limits the formation of a response set (Bailey, 1987; Judd *et al.*, 1991).

Comments such as 'You are being helpful. Can I now ask about meat?' provided a break and encouragement for the respondents as well as letting them know where they were in the interview. (Judd, 1991).

A number of questions were repeated under different sections of the QFFQ to provide a cross checking mechanism to improve accuracy (Bailey, 1987). In most instances these foods could fit into more than one category. For example:

- (a) Polony may be eaten on its own as a meat substitute or it may be eaten on bread as a sandwich filling. A respondent who only eats polony with bread might not think of it when it was grouped together with other types of meat, but might be reminded when it is asked about together with bread.
- (b) Custard was included under fruit as it is frequently eaten with canned fruit and so would

be associated with canned fruit. Better recall is obtained when foods eaten at the same time are grouped together (Smith-Barbaro *et al.*, 1982) . However, custard may also be eaten on its own or as with another type of desert such as jelly. Thus, custard was listed both under fruit and desserts.

- (c) Atchar could also fit into two categories of foods. It is frequently used as a spread on bread but is also eaten as a condiment with other foods.

The question: 'Are the amounts of samp and beans the same as in the picture?' was asked to try to ascertain the proportion of samp and dried beans used by the respondent in relation to the amounts shown in the food photograph.

A cross checking question for the portion size of stiff maize meal porridge was included with the question on tomato and onion sauce. The portion size photograph showed the tomato and onion sauce with the 500 g portion of stiff maize meal porridge. The subject was asked if the amount normally eaten was the same as, smaller or greater than the portion shown in the photograph. The answer was compared to the portion size indicated in the first question on stiff maize meal porridge. If the portion sizes differed, the subject would be shown the photographs of the stiff maize meal porridge again to either confirm or correct the first answer.

Spreads were grouped with bread as they are eaten together (Smith-Barbaro *et al.*, 1982; Feuerstein, 1986; Judd *et al.*, 1991) . Bread was placed here rather than with the cereals as the preliminary study showed that, particularly in the rural and farm areas, it did not constitute a large part of the diet. The brand names of butter and margarine were asked to check whether respondents actually used butter or whether they called margarine 'butter'. Also, the brand name was necessary to determine the type of margarine (hard, polyunsaturated or medium fat) used. Cross-checking questions for the use of margarine were added under the 'Fats used in cooking' to find out how different types of fats were used and to confirm the answers given under bread spreads and vegetable preparation.

Questions on the use of milk and sugar were asked together with foods with which milk is

associated, that is porridge, breakfast cereals, tea and coffee. This was done as respondents would find it easier to estimate small amounts used together with other foods (Smith-Barbaro *et al.*, 1982) than to estimate the total amounts used during the day.

The questions on salt use were included in an attempt to describe the amount of salt used. As it is extremely difficult to quantify the amounts of salt used, these questions could be used to identify respondents as low, medium or high salt users. The questions regarding the keeping of cooked food were asked to determine whether starches, especially maize meal, were eaten cold, with reference to resistant starch. The final question on supplement use was asked in case respondents made use of dietary supplements.

After the IS had been drawn up it was given to four experienced nutritionists for comment on the ease of use, understandability and completeness. These comments were used to refine the IS as follows:

- (a) The sequence of response options was changed from descending to ascending order in all the questions regarding acculturation.
- (b) The response options to Part II, question 4, were expanded and described in more detail for clarity.
- (c) Examples of venues for eating out were added to Part II, question 5 (Meals eaten away from home) in order to clarify the question. A question was added to ascertain the frequency of eating meals away from home (daily, weekly, monthly, less than once a month, never).
- (d) Additional preparation options were added to some of the foods listed in the QFFQ. For example, 'grilled' was added to beef, mutton and pork; 'with batter/crumbs' and 'without batter/crumbs' were added to fried fish; 'sour' was added to types of milk and 'with fat' and 'without fat' were added to tomato and onion sauce.
- (e) Several food items were added to the QFFQ including chicken feet, sweet potatoes,

mangoes, grapes, yoghurt, insects, wild animals and wild birds.

- (f) Examples of wild fruit were added to the question regarding wild fruit.

5.3.4 Pretesting of the interview schedule

The IS and the food portion photograph book (FPPB), were pretested on a group of 10 Tswana speaking volunteers (seven females and three males) (Chapter 4:4.3.1.5). Volunteers were asked to comment on the interview with regard to clarity and understandability of questions, whether they felt reluctant to answer any of the questions, the length of the interview and the relevance of the questions. The interview took approximately 45 minutes to complete. The pretest highlighted the following shortcomings of the IS:

- (a) Question 4, Part I (How are meals served in your family?) did not make allowance for people living alone or in residences or hostels.
- (b) The instructions given on the IS for questions 3 and 4 in Part I, were not clear as to whether respondents should answer both questions or whether urban respondents should only be asked Question 3 and rural and farm subjects Question 4.
- (c) In the QFFQ, too little space was allowed for 'other' options.
- (e) The questions regarding the use of fats in cooking were difficult to answer as normally food was prepared for the whole household. Thus, it was difficult for the respondent to estimate the amount of fat used for one person.

The IS was changed to overcome the above problems. It was then translated into Tswana by a qualified professional Tswana translator at the PU for CHE and into Afrikaans by Afrikaans speaking nutritionists at the PU for CHE.

The final QFFQ consisted of 145 food items. In addition, most food items were subdivided into different preparation methods. The final addition to the QFFQ was to print the food codes

used in the dietary analysis program (Grant *et al.*, 1992) and the recipe codes next to the foods to facilitate coding.

5.4 FIELD WORKERS

5.4.1 Recruitment

Five field workers for the study were recruited from the participants in the preliminary study who lived in Ikageng. All were Tswana speaking women with at least a Standard 8 school leaving certificate. The field workers were given temporary appointments at PU for CHE for the duration of the study.

5.4.2 Training

A detailed training manual was compiled by the researcher. The field workers underwent training by the researcher for three days one week prior to the commencement of the study. The programme for training was as follows:

Day 1: The aims and the data collection methods of the THUSA project in general and the dietary intake study in particular were described. The results of the preliminary study were discussed to give the field workers feedback from their participation in the preliminary study and to describe how these results were used in the development of the IS and the planning of the dietary intake study. The role of the field workers and interview techniques were described.

Day 2: The IS was explained question by question together with the FPPB and samples of food containers. The field workers interviewed each other. After the first set of interviews problem questions were discussed. The field workers then changed places, so that each field worker had a chance of being both an interviewer and a respondent.

Day 3: The field workers interviewed Tswana speaking volunteers from the Department of

Nutrition and Family Ecology at PU for CHE. The researcher and supervisor assessed the interviews and discussed problems with the field workers and reviewed the interview procedure.

During the training sessions it became apparent that some of the terms used in the Tswana translation were not familiar to the field workers. These were discussed and the best wording reached by consensus.

During the first week of the study the researcher checked all the completed IS schedules and discussed them with the field workers. Thereafter, the researcher checked random IS of each field worker and discussed problems with them. Discussions with all field workers as a group were held regularly throughout the research period.

5.4.3 Inter-rater reliability

Inter-rater reliability was tested by each of the five field workers interviewing the same five subjects (workers from the Department of Nutrition and Family Ecology, PU for CHE). Spearman Rank correlation coefficients and ANOVA were used to test agreement between raters.

5.5 SAMPLE SELECTION

5.5.1 Study design

The THUSA study was designed to compare the prevalence and severity of known risk factors for noncommunicable diseases (NCD) in Africans of the North West province at different levels of urbanisation. A cross-sectional representative sample of apparently healthy individuals from the African population was recruited and stratified for gender (two strata), age (five strata) and level of urbanisation (5 strata). Thus, a total of 50 cells (2x5x5) was required.

5.5.2 Sample size

The desired sample size for the THUSA study was based on the largest variation in nutrient

intakes (vitamins A and C) reported in the VIGHOR study (Vorster *et al.*, 1995). In order to show significant differences between subjects eating a wide variety of food, it was calculated that at least 50 subjects were needed in each cell, giving a total sample size of 2500. However for subjects eating a limited diet with a smaller variety of foods, smaller numbers would show significant differences. Practical considerations such as time, distances to centres and resources limited the desired sample size to 1250 (25 subjects per cell).

5.5.3 Age ranges

Non communicable diseases (NCD) are diseases of adulthood but may start developing in childhood. Therefore, it was decided to include subjects from 15 to 65 years of age in the sample. Older persons were not included because of the pronounced effect of age on most NCDs. Subjects were grouped into five age groups: 15-24,9; 25-34,9; 35-44,9; 45-54,9; 55-65.

5.5.4 Sampling technique

Multistage sampling procedures were used to select a random, representative sample of all apparently healthy adult Africans in the North West province.

With the help of the Biostatistics Consultation Services of PU for CHE, a model was designed to recruit a representative sample. In the first stage of sampling, the North West province was divided into quarters and five centres within each quarter were selected randomly. The second stage of sampling involved selecting four suitable locations (such as clinics, hospitals, schools, factories) from which to work within each area. The requirements for each centre were that a temporary field laboratory could be set up centrally for all locations, that the locations were accessible and that accommodation was available for the research team. Furthermore, the five centres within each quarter of the province should have access to subjects from all five strata of urbanisation. Contact was made with local authorities in all areas for permission to conduct the study and for assistance in recruiting subjects.

In practice, the selection of areas and locations were not truly random. Not all authorities approached gave permission for the study to be carried out in their communities or at a specific

location.. In addition, practical considerations such as accessibility and available facilities determined whether a venue could be used as a data collection point.

Table 5.1 shows the strata for the levels of urbanisation, the definitions of these strata and the areas selected (see also Figure 3.1)

Table 5.1 Stratification for levels of urbanisation

Stratum	Definition	Areas selected	Venues
Rural	Areas which fall under the authority of a traditional tribal head.	Groot Marico district, Madikwe	Community centre clinic, private home
Farm	African farm workers living on white owned farms. Subjects lived in brick houses clustered on the farm. Running water and electricity were available on some, but not all, farms.	Farms in the districts of Potchefstroom and Schweizer-Reneke	Suitable venue provided by farmer eg sheds
Informal settlement	Housing areas next to established towns. Subjects lived in temporary houses made from corrugated iron and other materials. Communal taps and electricity were available in some areas.	Top City (Ikageng), Tshing, Jouberton	Clinics
Middle class urban	Established African towns. Houses were brick and most had their own running water and electricity.	Ikageng, Jouberton, Tshing, Tlabane, Mmabatho	Clinics Schools Factory
Upper class urban	Politicians, executives and professionals living in established cities	Rustenberg, Tlabane, Mmabatho	Schools, the University of North West, Department of Health offices

The Latin-square design was used to control for seasonal effects.

Recruitment of subjects at each location was done in conjunction with a local community organiser. In each area, volunteers meeting the inclusion criteria were recruited until the required number of subjects in each stratum was attained. On the farms, all workers meeting the inclusion criteria and willing to participate were recruited.

5.5.5 Exclusion criteria

The exclusion criteria for the THUSA study also applied to the dietary intake study. Pregnant and lactating women, persons with known chronic diseases (such as hypertension and diabetes), persons with acute illness or injury, mentally retarded or ill persons and visitors to the area were excluded. In addition, because subjects had to look at the photographs in the FPPB, blind and visually impaired persons were excluded from the dietary intake study.

5.5.6 Ethical considerations

The study was approved by the Ethics Committee of the PU for CHE. Subjects were asked to sign an informed consent form consenting to participate in the study and giving permission for the drawing of blood samples.

5.6 DATA COLLECTION PROCEDURES

5.6.1 THUSA study

Each centre was visited by the THUSA project leader and another member of the research team. A suitable person, from the Department of Health Regional Offices or the Tribal Office was identified to help with the organisation of the field visits and the recruitment of subjects. The local organiser helped to identify the four locations around the centre which would serve as data collection points. The necessary permission to do the study was obtained from the relevant authorities (tribal chief, mayor, clinic head, hospital matron, school principals or employers). Each local organiser received copies of a brochure explaining the study and giving information requirements and instructions for distribution among possible subjects. Volunteers were instructed to bring their identity document to the data collection point (to ascertain the accurate date of birth) and to fast for eight to 12 hours (in preparation for the glucose tolerance test).

At the beginning of each data collection session, the purpose and procedures of the THUSA study were explained to the volunteers as a group by one of the Tswana speaking field workers. Volunteers were interviewed individually to check whether they met the inclusion criteria,

understood the purpose and procedures of the study, assigned a study number and asked to sign (signature or cross for illiterate subjects) an informed consent form (Appendix G). Each subject was given a card on which the data collection stations were printed. The researcher at each station signed when the test or interview was completed. The cards were used to control that subjects had completed all aspects of the study.

The data collection for the THUSA study comprised the following eight data collection stations:

- (a) Demographic questionnaire
- (b) Dietary intake interview
- (c) Anthropometric measurements
- (d) Clinical assessment, blood pressure, oral temperature and blood sample collection
- (e) Glucose tolerance test
- (f) Cardiovascular reactivity (stress) test
- (g) Spot urine sample
- (h) Reproductive interview (females only)

Data collection from each subject took approximately three hours. On completion of data collection, each subject was given immediate feedback by the study leader on blood pressure, glucose tolerance and anthropometry. Subjects who were found to have high blood pressure, glucose intolerance or other signs of ill health were given referral letters to the nearest clinic or hospital. Once blood samples had been analysed, individual feedback forms were sent to all participants.

As only the anthropometric assessment, dietary assessment and demographic interviews are relevant to the present study, only these procedures will be described..

5.6.2 Anthropometry

Subjects were weighed in light clothing without shoes to the nearest 0,05 kg on a portable electronic bathroom scale (Precision Health Scale, A & D Company, Japan). Height was measured to the nearest 0,5 cm with an upright stadiometer placed against a perpendicular wall. Subscapular and triceps skin-fold thicknesses were measured to the nearest 0,1 mm using a John

Bull calliper (British Indicators, London) following standard procedures. The average of three readings was taken. Waist and hip circumferences were measured with a steel tape around the smallest and widest parts of the waist and hips respectively. Age was calculated from the date of birth, obtained from the subject's identity document. Appendix H shows the anthropometric data collection sheet.

5.6.3 Dietary intake interview

Subjects were interviewed individually in their own language using the IS and FPPB by the field workers. Samples of food containers, such as milk powder packets, cans, cartons, snack packets, cold drink bottles, margarine tubs and sweet wrappers were used to help subjects describe their food intakes. Examples of cups, spoons and dishes were also available. As the field worker asked about a food, the subject indicated the portion size usually consumed by pointing to one of the photographs in the FPPB. The subject was then asked how many times per day, per week or per month the food was consumed. Each dietary intake interview took 30 to 45 minutes to complete.

5.6.4 Demographic questionnaire

The demographic questionnaire covered home language, ethnic group, health history, medication use, smoking and alcohol use, income, employment, education level and activity patterns.

5.7 STATISTICAL ANALYSES

5.7.1 Anthropometric data

Body mass index (BMI) was calculated using the formula $\text{weight(kg)}/\text{height(m)}^2$. Weight, gender and age were used to calculate the basal metabolic rate (BMR) using the formulae given in Table 5.2 (Schofield, 1985).

Table 5.2 Equations for the estimation of basal metabolic rate (Schofield, 1985).

Age group	Males BMR*	Females BMR*
10 - 18 years	$0,074 \times \text{wt}^{**} + 2,754$	$0,056 \times \text{wt}^{**} + 2,898$
19 - 30 years	$0,063 \times \text{wt}^{**} + 2,896$	$0,062 \times \text{wt}^{**} + 2,036$
31 - 60 years	$0,048 \times \text{wt}^{**} + 3,653$	$0,034 \times \text{wt}^{**} + 3,538$
Over 60 years	$0,049 \times \text{wt}^{**} + 2,459$	$0,038 \times \text{wt}^{**} + 2,755$

* BMR= basal metabolic rate expressed in MJ/24 hours; ** wt= weight expressed in kg

BMR was converted to kilojoules to be comparable to the energy intake. All calculations were done by using the Foxpro Relational Database Management System (Microsoft, 1993). Mean BMI was compared across age and urbanisation strata using the Analysis of Variance (ANOVA). The Statistica release 5 (Statsoft, 1995) statistical analysis program was used for statistical analyses.

5.7.2 Acculturation and food pattern data

The data obtained from the acculturation and food pattern questionnaires and the questions concerning food procurement, salt use and the keeping of food were entered onto a database using the Foxpro software (Microsoft, 1993). Responses to questions were categorised into frequency distributions. Associations between variables and strata of acculturation were tested using the Chi squared test.

5.7.3 Dietary data

The dietary data obtained from the QFFQ was processed prior to statistical analysis in the following stages:

- (a) The weight of each food was calculated as grammes per day from the weight of the portion size and the frequency of consumption. Calculations were done manually by a qualified dietitian and checked by the researcher. The weights of foods consumed daily were calculated by:

weight of portion x frequency of consumption/time period

where time period is per day=1; per week=7; per month=30; seldom=60

Seasonal foods such as fruit and vegetables were adjusted for seasonal variation. For example, the weight of maize calculated per day was divided by two to adjust for fresh maize only being available during the summer (November to March), the amounts for fresh oranges, grapes and peaches were divided by three on the assumption that these fruits are readily available for approximately four months of the year, and the weight of apricots and mangoes were divided by four as these fruits are generally available for three months of the year.

Since the consistency of maize meal and sorghum porridge varies from individual to individual, the weights of the portion sizes were converted to the equivalent weight of dry meal. The following average conversion factors, based on the findings of the preliminary study and published recipes (Cuzen, 1983; Langenhoven *et al*, 1991b) were used:

Very stiff:	Cooked weight x 0,4
Stiff:	Cooked weight x 0,3
Medium soft:	Cooked weight x 0,2
Soft:	Cooked weight x 0,1

- (b) The food and recipe codes and amounts were entered into the FoodFinder dietary analysis program by the researcher. Recipes that were derived from the preliminary study were entered as recipes into the dietary analysis program and were used for the nutrient analyses. Each QFFQ was analysed and printed immediately after input and then checked with the original QFFQ.
- (c) To check the accuracy of the data input, after completion of data input, the means and standard deviations for energy, total protein, total fat, calcium, iron, vitamin A and vitamin C were calculated. The original QFFQ of subjects whose values lay outside of the mean $\pm$ two standard deviations were checked and corrected if necessary. To check the data input further, every tenth QFFQ was selected and compared to the print-out of foods from

the dietary analysis.

- (d) In order to analyse the food consumption, a separate data base was created containing the foods and the amounts consumed by each subject. Total consumption of foods was calculated in grammes per day by a programme written using the Foxpro software (Microsoft, 1993) and printed in descending order of the amount. This list was used to cross check the accuracy of the data input. All unusual foods such as alfafa seeds or foods not usually consumed by the study population such as cream, salmon or turkey, were checked against the original QFFQ in case a coding error had been made.
- (e) As a final check of the accuracy of input, the means and standard deviations of the corrected data were calculated. QFFQ with values still lying outside of the mean $\pm$ two standard deviations were checked again. If the data input corresponded to the original QFFQ, the questionnaire was discarded from further analyses as unrealistic.
- (h) The percentage contribution by carbohydrate, total protein and total fat was calculated from the energy provided by the macronutrient divided by the total energy content of the diet, expressed as a percentage. Likewise, the saturated fat, monounsaturated fat and polyunsaturated fat were expressed as percentages of the total fat intake.
- (g) Energy and nutrient intakes were expressed in both absolute amounts as well as percentages of the Recommended Dietary Allowances (RDA) (Food and Nutrition Board, 1989). For energy and protein the recommended allowances were calculated individually for each subject based on body weight.
- (h) Actual food consumption data was summarised by combining foods into food groups. Foods were group according to the Five Basic Food groups (Department of Health Services and Welfare, 1992). However, in order to facilitate comparisons between strata for specific foods, maize meal, red meat, chicken, legumes and others were kept separate from the cereal and protein-rich food group. Table 5.3 shows the foods group classification used in the analyses. The percentage contribution of each of the food groups to the total energy intake was calculated. The number of standard portions from each of

the food groups was calculated using the Diabetic Exchange Groups (Bloch & Shils, 1994) as reference and following the procedure of Langenhoven *et al.* (1988b). Table 5.4 summarises the calculation of food group portions. All calculations were done using programs developed by using the Foxpro software (Microsoft, 1993).

Table 5.3: Classification of foods into food groups

Food group	Foods included in group
Maize meal	Maize meal white: super; special enriched; unsifted
Samp	Samp; maize rice
Rice	White rice
Breakfast cereals	Corn Flakes, All Bran Flakes, Weet-Bix, Rice Crispies
Bread	White, brown and whole wheat bread and bread rolls; fat cakes, rusks; crisp breads
Other cereals	Sorghum (Mabella); oats; pasta
Red meat	Beef; mutton; pork; internal organ meat; sausage; processed and canned meat All preparation methods
Chicken	White and dark chicken meat; chicken feet; chicken livers and offal. All preparation methods
Fish	Hake, fried with or without batter; canned fish
Eggs	Boiled, fried or scrambled
Legumes	Dried beans, peas and lentils
Milk	Full cream, 2% and fat free fresh, long life or powdered; sour milk; cheese; custard; yoghurt; milk drinks
Fruit	Fresh and canned fruit; fruit juice
Vegetables	Fresh, frozen and canned vegetables. All preparation methods.
Fats	Margarine, vegetable fat, butter, lard, oil, mayonnaise, cream, ice-cream.
Sugar	Added sugar, jam, honey, syrup
Sweets	Candies, chocolates
Sweetened drinks	Carbonated beverages, cordials, squashes
Mageu	Mageu
Alcohol	Beer; sorghum beer; home brewed beer; wines; spirits

Table 5.4: Calculation of the number of portions from each of the food groups

Food	* Formula	Diabetic Exchange group	One exchange	Number of exchanges per portion
Milk	protein/8	milk	8 g protein	1
Cheese	protein/8	milk	8 g protein	1
Red meat, chicken, fish	protein/21	meat	7 g protein	3
Egg	protein/6	meat	6 g protein	1
Legumes	protein/7	meat	7 g protein	1
Fruit	**CHO/15	fruit	15 g **CHO	1
Vegetables	**CHO/5	vegetables	5 g **CHO	1
Potato	**CHO/15	vegetables	15 g **CHO	1
Cereals	**CHO/15	bread	15 g **CHO	1
Fat	Fat/5	fat	5 g fat	1

*Formula: macronutrient expressed in grammes divided by the number of grammes of that nutrient in a diabetic exchange; **carbohydrate.

All the nutrient and food databases were imported into the Statistica program (Statsoft, 1995) for statistical analyses.

Descriptive statistics (means, standard deviations, confidence intervals and frequency distributions) were calculated. Differences in mean intakes were tested using the analysis of variance (ANOVA) procedure. Significant F-values were further tested using the Tukey test for honest significant differences (HSD) with the level of significance set at 0,5%. The distributions of subjects with intakes of the indicator nutrients (energy, protein, calcium, iron, vitamin A and vitamin C) and niacin were defined. Differences in the percentages of subjects with intakes below 67% RDA were tested for significance (Statsoft, 1995). The level of significance was determined by the Bonferroni adjustment (Miller, 1981) by which the desired P-value is divided by the number of groups being compared. Thus significance was taken as a P-value less than 0,01 ($0,05 \div 5$).

5.8 CONCLUSION

This chapter described the methods used for the design and testing of the QFFQ, the recruitment and training of the field workers, the overall design of the THUSA study, the implementation of the dietary intake interviews and the analysis of the data. The methods used specifically to test the reproducibility and relative validity of the QFFQ are described in Chapter 6 and Chapter 7 respectively.

CHAPTER 6

REPRODUCIBILITY

6.1 INTRODUCTION

The reproducibility of a questionnaire is measured by its ability to obtain similar results when administered at different times to the same subjects. Thus, the reproducibility of the QFFQ was tested on a subsample of volunteers from the THUSA study. Volunteers were drawn from both genders, from all strata of urbanisation, and from all age groups. The reproducibility study was conducted concurrently to the main THUSA study with an interval of six to 12 weeks between repeat administrations. This chapter describes the methods and subjects used and discusses the results of the reproducibility study of the QFFQ and FPPB.

6.2 METHODS

6.2.1 Sample

6.2.1.1 Sample size

The desired sample size was estimated as 5% (125) of the total planned THUSA sample.

6.2.1.2 Selection of subjects

Only volunteers were recruited for the reproducibility study. At the end of the dietary intake interview, the field worker explained the purpose of the reproducibility study to the subject and asked if he or she would be willing to undergo the QFFQ a second time, approximately two months later. If the subject consented, his or her name, address, telephone number /s (when available), directions to the home and those of another contact person (such as a relative, friend or employer) were obtained (Appendix I). As much information as possible was obtained about the subject's place of residence to facilitate tracing them. Each subject was given a letter explaining the purpose of the reproducibility study. It was emphasised that the subject would only

participate in the dietary intake interview again and that none of the other tests or interviews of the THUSA study would be carried out.

Volunteers for the reproducibility study were recruited from each stratum of urbanisation but were not stratified for age and gender. It was hoped that the random selection and tracing of volunteers would give a representative sample.

6.2.1.3 Tracing of subjects

Prior to the return visit, the local organiser in each area was sent a list of the names and addresses of the volunteers and asked to contact them and arrange for them to meet at the data collection centre. In some instances, such as schools, the University of North West and the farm the research team visited the specific venue. An attempt was made on the day of the return visit to trace those volunteers who did not come to the data collection centre. Usually a clinic nurse or other person who knew the area very well helped with the tracing. Although volunteers were recruited from all the farms, only one farmer gave permission for the return visit. All subjects on this farm were interviewed, irrespective of whether they had volunteered previously.

6.2.2 Data collection

The repeat interviews took place six to 12 weeks after the first interview. The timing of the return visit to an area depended on several practical considerations. First, the repeat visit had to fit in between the visits of the THUSA team for the main study. Second, the timing of the visit depended on the availability of the local organiser to trace subjects and the availability of the venue for data collection.

Subjects were interviewed using Part II (Food pattern) and Part III (QFFQ) of the interview schedule. A question was added at the beginning of the interview to ascertain whether the subject's circumstances had changed in any way since the first interview. The FPPB and food package samples were used in the same way as they had been in the initial interview. Subjects were randomly assigned to field workers. Field workers did not necessarily interview the same subjects as in the first interview. This was for practical reasons. There was no way to predict

which volunteers would return for the repeat interview. Thus, one field worker might have had several subjects waiting to be interviewed while another had no subjects. This would not have been efficient, either from the point of view of the subjects who would have been kept waiting or of the research team, who would have had to spend more time at each centre. Also, two of the field workers helped with tracing while the other three conducted the interviews.

All subjects were given a kilogramme packet of dry beans (donated by the Dry Bean Producers Organisation) as a token of appreciation.

6.2.3 Statistical analyses

The meal pattern and dietary data were coded and computerised as described in Chapter 5. Reproducibility was tested for energy, total protein, total fat, total carbohydrate, fibre, cholesterol, calcium, iron, vitamin A and vitamin C. It was assumed that results obtained from the comparison of these nutrients and food groups would be representative of the whole diet (Larkin *et al.*, 1989). Reproducibility was tested for all food groups.

For both nutrients and food groups, rank correlations between first and second administrations of the QFFQ were calculated using Spearman rank correlation coefficients, differences between means were tested by the t-test for paired samples and the correlation of the mean of the two administrations of the QFFQ against the difference of the QFFQ by Bland-Altman plots (Bland & Altman, 1986; 1995). Correlation coefficients between males and females, age groups, levels of urbanisation and category of BMI were compared. The Statistica software (Statsoft, 1995) was used for all the above statistical procedures with the significance level set at five per cent. In addition, the distributions of the intakes reported from the two administrations of the QFFQ were divided into quintiles and the number of subjects falling into the same or adjacent quintile on each administration calculated. The cut-off points for the quintile distributions were calculated for each administration separately. These latter procedures were written using the Foxpro 2.6a software (Microsoft, 1993)

6.3 RESULTS

6.3.1 Sample description

The final sample for the testing of the reproducibility of the QFFQ comprised 144 subjects (99 females and 45 males) from all five strata of urbanisation for whom both the first and the second QFFQ were usable. Table 6.1 shows the frequency distribution of gender and Table 6.2 the frequency distribution of age according to strata of urbanisation.

Table 6.1: Distribution of gender according to strata of urbanisation (N=144)

Stratum	Males		Females		Total	
	N	%	N	%	N	%
Rural	15	10,4	19	13,2	34	23,6
Farms	10	6,9	10	6,9	20	13,9
Informal settlement	3	2,1	25	17,4	28	19,5
Middle class urban	4	2,8	28	19,4	32	22,2
Upper class urban	13	9,0	17	11,8	30	20,8
Total	45	31,2	99	68,8	144	100,0

Table 6.2: Distribution of age according to strata of urbanisation (N=144)

Stratum	Age (years)											
	15 - 24,9		25 - 34,9		35 - 44,9		45 - 54,9		55 - 64,9		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Rural	3	2,1	9	6,3	11	7,6	8	5,6	3	2,1	34	23,6
Farms	2	1,4	3	2,1	8	5,6	5	3,5	2	1,4	20	13,9
Informal settlement	8	5,6	10	6,9	4	2,8	4	2,8	2	1,4	28	19,5
Middle class urban	2	1,4	19	13,2	8	5,6	0	0	3	2,1	32	22,2
Upper class urban	1	0,7	16	11,1	8	5,6	5	3,5	0	0	30	20,8
Total	16	11,1	57	39,6	39	27,1	22	15,3	10	6,9	144	100

The strata of urbanisation were fairly evenly represented except for the farm workers who made up only 14% of the sample. Females in the 25 to 34,5-year age group made up the largest proportion of the sample (26%) while males in the age group younger than 25 years were the least representative in the sample (3%). Apart from the age groups younger than 25 years and between

25 and 34,9 years, the age, stratum of urbanisation and gender distributions of the reproducibility sample were not significantly different from those of the THUSA sample ($P>0,05$). The percentage of subjects younger than 25 years (11%) in the reproducibility sample was significantly less than that of the THUSA sample (26%) ($P<0,001$). However, in the 25 to 34,9-year age group, the percentage of subjects in the reproducibility sample (40%) was significantly higher than that of the THUSA sample (25%) ($P<0,01$). When the two age groups were taken together, the difference in percentages of subjects younger than 35 years of age (51% for the reproducibility sample and 49% for the THUSA sample) was not significantly different ($P>0,05$). With regard to education level, the majority of the sample (55%) had a high school education, while 25% had no schooling or less than a standard two education.

Table 6.3 shows the mean age ($\pm$ SD) and BMI ($\pm$ SD) for males and females for the different strata of urbanisation.

Table 6.3: Mean ($\pm$ *SD) age and body mass index of females and males (N=144).

Stratum	Age (years)				**BMI			
	Males Mean *SD		Females Mean *SD		Males Mean *SD		Females Mean *SD	
Rural	39,57	14,24	39,74	10,45	22,02	5,39	26,75	8,47
Farms	46,90	12,21	36,00	10,56	19,26	1,25	25,16	8,82
Informal settlement	25,67	6,65	35,64	12,14	21,00	2,6	28,92	8,19
Middle class urban	36,75	14,24	34,54	10,05	23,55	4,34	27,95	7,46
Upper class urban	32,54	6,06	36,65	9,16	24,42	4,42	27,36	6,11
Total	38,02	12,62	36,32	10,55	22,17	4,49	27,58	7,71

*SD: standard deviation; **BMI: body mass index =weight (kg)/ height (m²)

The mean age of the sample was 36,85 years (SD=11,22). There was no significant difference between the mean age of the females (36,3 SD=10,6 years) and the males (38,0 SD=12,6 years) ($P>0,05$). The mean ages of the rural (39,71 SD=12,1 years) and the farm (41,5 SD= 12,4 years) strata were higher than the mean ages of the other three strata (34,6 SD=12,0 years, 34,8 SD=10,4 years and 34,9 SD=8,1 years for informal settlements, middle class and upper class urban respectively). However, this difference was not statistically significant ($P>0,05$).

There was no significant difference between the mean BMI of either the males or the females in all strata ($P>0,05$).

The mean time between first and second interviews was 58 days ($SD=27$ days) with a range of 22 to 86 days.

6.3.2 Comparison of results of reported nutrient intakes between administrations of quantitative food frequency questionnaire

6.3.2.1 Spearman rank correlation coefficients for nutrients

The Spearman rank correlation coefficients were calculated to determine the agreement between the first and second administrations of the QFFQ. Table 6.4 shows the correlation coefficients for the sample as a whole and for females and males separately.

Table 6.4: Spearman rank correlation coefficients between first and second administrations of the quantitative food frequency questionnaire (N=144)

Nutrient	Entire sample N=144		Males N=45		Females N=99	
	§R	¶95% CI	§R	¶95% CI	§R	¶95% CI
Energy	0,278	0,120-0,422***	0,214	-0,085-0,478	0,256	0,062-0,432*
Total protein	0,307	0,151-0,448***	0,345	0,057-0,580*	0,275	0,082-0,448***
Total carbohydrate	0,216	0,050-0,367***	0,147	-0,153-0,422	0,199	0,002-0,381*
Total fat	0,389	0,241-0,520***	0,474	0,210-0,674***	0,323	0,134-0,489***
Cholesterol	0,395	0,247-0,525***	0,252	-0,045-0,508	0,458	0,268-0,601***
Fibre	0,285	0,127-0,430***	0,418	0,142-0,634**	0,212	0,015-0,393*
Calcium	0,141	-0,231-0,292	-0,043	-0,332-0,254	0,211	0,014-0,392*
Iron	0,278	0,120-0,420***	0,291	-0,003-0,539	0,264	0,070-0,439**
Vitamin A	0,339	0,186-0,476***	0,306	0,014-0,550*	0,360	0,175-0,520***
Vitamin C	0,382	0,233-0,513***	0,374	0,090-0,602*	0,380	0,197-0,537***
Alcohol	0,745	0,662-0,810***	0,638	0,424-0,785***	0,684	0,563-0,777***

Level of significance: * $P<0,05$; ** $P<0,01$; *** $P<0,001$; §R: Spearman rank correlation coefficient; ¶95% CI: 95% confidence interval

The strongest correlations were for alcohol (0,75) for the entire sample, for females (0,68) and males (0,64) while the weakest correlation was for calcium (0,14) with the males showing a slight negative correlation (-0,04). Except for protein, total fat, fibre and iron, the correlation coefficients for the males were weaker than for the females (possibly due to the considerably smaller sample size) with no significant correlation being found for energy, total carbohydrate, cholesterol, calcium and iron. However, none of the Spearman rank correlation coefficients was significantly different for males and females ($P>0,05$).

In order to determine whether reproducibility was affected by stratum of urbanisation, age or BMI, Spearman rank correlation coefficients were calculated for these subgroups. The correlation coefficients according to stratum of urbanisation are given in Table 6.5, for age groups in Table 6.6 and for BMI in Table 6.7.

Table 6.5: Spearman rank correlation coefficients according to strata of urbanisation (N=144)

Nutrient	Rural N=34		Farm N=20		Informal Settlement N=28		Middle class urban N=32		Upper class urban N=30	
	§R	¶95%CI	§R	¶95%CI	§R	¶95%CI	§R	¶95%CI	§R	¶95%CI
Energy	0,323	-0,017-0,596	0,363	-0,095-0,694	0,203	-0,203-0,536	0,266	-0,910-0,563	0,221	-0,151-0,538
Total protein	0,280	-0,064-0,565	0,013	-0,432-0,453	0,137	-0,249-0,435	0,354	-0,006-0,625*	0,280	-0,089-0,582
Total carbohydrate	0,273	-0,718-0,560	0,353	-0,106-0,688	0,066	-0,315-0,429	0,232	-0,127-0,537	0,185	-0,188-0,511
Total fat	0,330	-0,009-0,601	-0,23	-0,611-0,236	0,273	-0,111-0,586	0,217	-0,142-0,526	0,296	-0,072-0,593
Cholesterol	0,386	0,055-0,641*	-0,34	-0,684-0,114	0,293	-0,090-0,06	0,473	0,149-0,705**	0,181	-0,192-0,508
Fibre	0,457	0,141-0,689**	0,246	-0,221-0,621	0,112	-0,272-0,466	0,194	-0,166-0,508	0,169	-0,204-0,499
Calcium	0,293	0,050-0,574	-0,43	-0,734-0,014	0,272	-0,112-0,586	0,417	0,079-0,668*	0,032	-0,332-0,388
Iron	0,072	-0,273-0,400	0,366	-0,091-0,696	0,115	-0,270-0,468	0,137	-0,222-0,464	0,214	-0,158-0,533
Vitamin A	0,271	-0,074-0,558	-0,06	-0,490-0,392	0,529	0,194-0,753**	0,136	-0,223-0,463	0,218	-0,154-0,536
Vitamin C	0,213	-0,134-0,514	0,013	-0,432-0,454	0,336	-0,042-0,630	0,181	-0,179-0,498	0,271	-0,999-0,578
Alcohol	0,706	0,483-0,843***	0,861	0,676-0,944***	0,461	0,106-0,712*	0,687	0,445-0,836***	0,768	0,564-0,884***

§R=Spearman rank correlation coefficient; ¶95% CI: 95% confidence interval

Level of significance: * $P<0,05$; ** $P<0,01$; *** $P<0,001$

When the sample was broken down into the strata of urbanisation, the only significant correlations were for alcohol for all strata and for fibre (rural), vitamin A (informal settlement), protein, cholesterol and calcium (middle class urban). A contrasting trend of negative (although not

significant) correlations for total fat, cholesterol, calcium and vitamin A appeared for the farm workers' stratum. The only significant differences among Spearman rank correlation coefficients occurred between the farm stratum and both the rural and the middle class urban strata for cholesterol and calcium ($P<0,01$).

Table 6.6: Spearman rank correlation coefficients according to age groups (N=144)

Nutrient	Age group (years)							
	15-24,9 N=16		25 - 34,9 N=57		35 - 44,9 N=39		45 - 64,5 N=32	
	§R	¶95% CI	§R	¶95% CI	§R	¶95% CI	§R	¶95% CI
Energy	0,150	-0,373-0,601	0,263	0,003-0,490*	0,241	-0,081-0,517	0,224	-0,135-0,531
Total protein	-0,071	-0,547-0,447	0,404	0,160-0,601**	0,278	-0,041-0,546	0,266	-0,091-0,563
Total carbohydrate	0,215	-0,314-0,642	0,173	-0,092-0,415	0,180	-0,144-0,446	0,192	-0,168-0,507
Total fat	-0,182	-0,345-0,622	0,419	0,178-0,613**	0,389	0,084-0,628*	0,304	-0,050-0,590
Cholesterol	-0,079	-0,433-0,554	0,419	0,178-0,613**	0,388	0,083-0,627*	0,493	0,174-0,718***
Fibre	0,187	-0,340-0,625	0,212	-0,051-0,448	0,274	-0,046-0,543	0,445	0,114-0,687**
Calcium	-0,229	-0,651-0,300	0,297	0,040-0,518*	-0,046	-0,356-0,273	0,196	-0,164-0,510
Iron	0,006	-0,491-0,500	0,193	-0,071-0,432	0,339	0,026-0,591*	0,337	-0,013-0,614
Vitamin A	0,038	-0,467-0,524	0,460	0,227-0,643***	0,290	0,032-0,521	0,430	0,096-0,677*
Vitamin C	0,361	-0,164-0,727	0,219	-0,043-0,455	0,515	0,238-0,714**	0,407	0,068-0,662*
Alcohol	0,625	0,187-0,856**	0,770	0,637-0,858***	0,704	0,499-0,834***	0,811	0,645-0,904***

§R=Spearman rank correlation coefficient; ¶95% CI: 95% confidence interval

Level of significance: * $P<0,05$; ** = $P<0,01$; *** $P<0,001$

Since the number of subjects in the age group 55 to 65 years was small (N=10), these subjects were combined with the age group 45 to 54,9 years for analysis. Again, alcohol showed the most significant correlation across all age groups. The weakest correlations occurred in the youngest age group (15 to 24,9 years). Stronger correlations occurred in the other age groups, especially for total protein (25 - 34,9 years), total fat (25 - 34,9 years; 35 - 44,9 years), cholesterol (25 - 34,9 years; 35 - 44,9 years; 45 - 65 years), fibre (45 - 65 years), vitamin A (25 - 34,9 years; 45 - 65 years) and vitamin C (35 - 44,9 years; 45 - 65 years). The only significant correlation for calcium occurred in the 25 to 34,9-year age group. However, there were no significant differences in correlation coefficients among age groups for any of the nutrients ($P>0,01$).

Table 6.7 Spearman rank correlation coefficients according to body mass index (N=144)

Nutrient	Body mass index (kg/m ²)					
	< 21 N=44		21 - 26,9 N=46		≥27 N=54	
	§R	¶95% CI	§R	¶95% CI	§R	95% CI
Energy	0,302	0,006-0,550*	0,268	-0,024-0,518	0,280	0,013-0,510*
Total protein	0,361	0,072-0,594*	0,259	-0,034-0,511	0,323	0,061-0,544*
Total carbohydrate	0,229	-0,073-0,492	0,234	-0,060-0,491	0,174	-0,098-0,422
Total fat	0,533	0,281-0,717***	0,277	-0,015-0,525	0,364	0,107-0,576**
Cholesterol	0,421	0,142-0,638**	0,376	0,096-0,601	0,372	0,116-0,582**
Fibre	0,255	0,045-0,0513	0,261	-0,032-0,512*	0,241	-0,029-0,478
Calcium	-0,097	-0,383-0,306	0,219	-0,075-0,479	0,274	0,007-0,505*
Iron	0,505	0,245-0,697**	0,094	-0,202-0,374	0,208	-0,063-0,451
Vitamin A	0,343	0,051-0,581*	0,449	0,182-0,654**	0,216	-0,055-0,450
Vitamin C	0,559	0,314-0,734***	0,210	-0,086-0,472	0,089	-0,188-0,348
Alcohol	0,786	0,638-0,878***	0,741	0,574-0,849***	0,639	0,448-0,774***

§R: Spearman rank correlation coefficient; ¶95% CI: 95% confidence interval

Level of significance: *P<0,05; ** = P<0,01; *** P<0,001.

More significant correlations between the first and second QFFQ appeared when the sample was divided into three subgroups according to BMI, than in any of the other subdivisions. This was probably due to the larger sample sizes of the subgroups. In the group with a low BMI, significant correlations were found for eight of the 11 nutrients examined, for the group with BMI within the normal range, three nutrients had significant correlations and in the overweight group, six nutrients were significantly correlated. Spearman rank correlation coefficients for iron and vitamin C were significantly higher for the group with a low BMI than for the group with a BMI between 21 and 27 kg/m² (P<0,05) and the group with a BMI higher than 27 kg/m² (P<0,05) respectively.

6.3.2.2 Paired t-tests for reported nutrient intakes between first and second administrations of the quantitative food frequency questionnaire

In order to test the reproducibility of the QFFQ on a group basis the mean reported intakes for the 11 nutrients were compared for the entire sample and males and females (Table 6.8), strata of urbanisation (Table 6.9), age groups (Table 6.10) and BMI (Table 6.11).

Table 6.8: Mean, standard deviation and difference between means of first and second administrations of the quantitative food frequency questionnaire (N=144)

		Entire sample N=144				Males N=45				Females N=99			
Nutrient		Mean	SD	+Diff ++%	±95% CI	Mean	SD	+Diff ++%	±95% CI	Mean	SD	+Diff ++%	±95% CI
Energy (kJ)	1 2	8295 8777	2882 3304	482 5,6	-124- 1039	9136 9812	3207 3566	675 7,1	-585- 1935	7913 8308	2651 3083	395 4,9	-292- 1082
Total protein (g)	1 2	63,0 69,6	21,4 26,5	6,6 10,0	2,0- 11,2**	68,7 77,1	24,5 28,3	8,3 11,4	-0,65- 17,3	60,4 66,2	19,5 25,1	5,8 9,2	0,46- 11,1*
Total carbohydrate (g)	1 2	297,9 295,6	122,3 114,1	-2,3 -0,8	-26,3- 21,7	330,8 336,6	135,1 125,0	5,8 1,7	-43,4- 55,0	283,0 277,0	113,6 104,3	- 6,0 - 2,1	-33,4- 21,4
Total fat (g)	1 2	56,0 66,3	25,2 32,6	10,3 17,0	4,9- 15,7***	55,7 68,0	28,9 34,4	12,4 20,0	2,0- 22,8*	56,1 65,1	23,5 31,9	9,5 15,7	3,2- 16**
Cholesterol (mg)	1 2	269,5 320,4	179,4 188,0	50,9 17,0	14,3- 87,5**	275,9 361,4	170,5 214,9	85,5 26,8	10,3- 16,1*	266,6 301,7	184,1 172,4	35,2 12,4	-6,2- 76,6
Fibre (g)	1 2	16,6 19,0	7,1 8,7	2,4 13,5	0,89- 3,9**	17,5 21,0	8,6 10,3	3,5 18,0	0,68- 6,3*	16,3 18,1	6,3 7,7	1,9 11,0	0,09- 3,7*
Calcium (mg)	1 2	487,1 503,0	264,8 260,2	15,9 3,2	-43,4- 75,2	530,9 544,5	278,2 261,0	13,6 2,5	-103- 130	467,2 484,2	257,5 259,0	17,0 3,6	-52,6- 86,6
Iron (mg)	1 2	8,5 9,7	3,9 4,1	1,2 13,2	0,39- 2,01**	8,4 10,6	3,9 4,6	2,2 23,2	0,61- 3,78**	8,6 9,3	3,8 3,8	0,7 7,8	-0,34- 1,6
Vitamin A (RE)	1 2	779,9 895,1	682,6 635,2	115 13,8	-9,9- 240	640,9 830,2	580,3 659,5	189 25,7	-51,5- 430	843,0 924,6	718,1 625,0	81,7 9,2	-66,1- 221
Vitamin C (mg)	1 2	54,1 67,4	78,2 59,2	13,3 22,0	-0,84- 27,5	50,1 67,4	87,8 65,1	17,3 29,4	-12,0- 46,6	55,9 67,4	73,9 56,7	11,5 18,6	-4,6- 27,7
Alcohol (g)	1 2	7,0 6,2	13,4 11,6	- 0,8 -12,1	-3,0- 1,42	14,3 12,1	17,5 13,9	- 2,2 -15,6	-7,7- 3,3	3,7 3,6	9,5 9,3	- 0,1 - 2,7	-1,4 - 11,7

¶SD= standard deviation; †Diff = mean of second - mean of first administration of QFFQ; ††%Mean diff=(mean QFFQ2- mean QFFQ1)/(QFFQ1+QFFQ2/2)*100; ‡95% CI: 95% confidence interval: Level of significance: *P<0,05; **= P<0,01; *** P<0,001

Table 6.9: Differences between first and second administrations of QFFQ according to strata of urbanisation (N=144)

		Rural N=34				Farm N=20				Informal Settlement N=32				Middle class urban N=30				Upper class urban N=28			
Nutrient		Mean	¶SD	†Diff ††%	95% CI	Mean	¶S D	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI
Energy (kJ)	1 2	7973 8560	3590 3719	588 7,1	894- 2070	8178 7310	2032 2422	-868 11,2	-2127 -391	8634 9600	2862 3364	966 10,6	-386- 2318	8321 9221	2747 3412	900 10,3	-577- 2377	8355 8674	2746 2935	320 3,8	-900- 1540
Total protein (g)	1 2	59,4 67,4	28,3 28,7	8,0 12,6	-2,8- 18,8	57,1 55,1	14,2 22,8	-1,9 3,4	-14,7- 10,9	67,3 77,2	19,9 27,1	9,9 13,7	-166- 19,6*	67,7 74,7	19,8 26,6	7,0 9,8	-3,7- 17,7	61,6 68,3	18,6 22,1	6,7 10,3	-2,7- 16,1
Total carbohydrate (g)	1 2	303,2 294,3	154,9 131,1	-8,9 -6,0	-69-51	336,3 272,5	111 82,9	-63,9 -21,0	-115- 12,9*	297,3 318,0	120,7 127,0	20,7 6,7	-34,5- 75,9	262,7 288,1	92,8 109,2	25,4 34,8	-23,1- 74,9	302,5 296,3	112,5 103,5	-6,3 -2,1	-60,2- 47,6
Total fat (g)	1 2	46,7 61,4	21,6 32,3	14,8 27,4	3,4- 26,2*	34,5 38,9	15,0 28,6	4,4 12,0	-12,6- 21,4	65,1 76,5	21,4 29,3	11,4 16,1	-0,46- 23,3	67,8 78,2	27,8 31,7	10,5 14,4	-3,3- 24,3	59,5 67,2	23,9 28,9	7,8 12,3	14,0- 33,8
Cholesterol (mg)	1 2	233,4 303,0	168,8 181,4	69,7 26,0	-8,8- 148	141,2 195,0	86,2 206	53,9 32,1	-54,7- 162	310,0 353,1	198,7 157,8	43,2 13,0	-29,6- 116	305,6 364,5	141,3 172,1	58,9 17,6	-17,7- 138	320,0 346,3	209,2 201,4	26,3 7,9	-74,5- 124
Fibre (g)	1 2	15,3 20,1	9,0 9,5	4,8 27,1	1,7- 7,9 **	13,0 13,7	4,2 7,1	0,7 5,2	-3,0- 4,4	18,1 22,5	6,8 9,9	4,4 21,6	-0,58- 8,22	17,8 18,2	6,5 7,0	0,4 2,2	-2,7- 3,5	17,9 18,5	6,2 7,0	0,6 3,3	-2,9- 4,1
Calcium (mg)	1 2	484,4 442,6	296,1 246,8	-41,8 9,0	-163- 79,3	680,2 546,5	362 347	-134 21,8	-150- 418	414,8 528,6	180,0 228,7	114 24,1	30,2- 197**	504,8 575,7	216,5 294,7	70,9 13,1	-58,2- 200	416,3 438,3	211,8 170,4	22,0 5,1	-68- 112
Iron (mg)	1 2	8,0 9,6	4,1 3,8	1,5 17,0	-0,4- 3,4	5,6 6,3	2,5 3,4	0,7 11,8	-1,14- 2,6	8,8 10,7	3,0 4,1	1,9 19,5	.205- 3,59*	10,4 10,6	4,4 0,2	0,2 1,9	-1,8- 2,2	9,0 10,3	3,4 4,3	1,3 13,5	-0,52- 3,12
Vitamin A (RE)	1 2	579,3 881,5	681,9 724,0	302 41,3	7,9- 596*	351,1 540,3	234 495	189,2 42,5	-76,8- 455	849,6 1001	700,1 591,2	152 16,4	-160- 462	1199 985	719,1 599,9	-215 -19,7	-482- 52,4	800,0 947,7	594,2 645,7	148 16,9	-91,2- 387*
Vitamin C (mg)	1 2	38,4 81,4	91,2 69,1	42,9 71,6	4,3- 81,7*	14,3 14,1	9,8 9,1	-0,2 -1,4	-7,0- 6,6	70,6 77,1	101,6 61,9	6,5 8,8	-32,1- 45,1	92,4 79,1	69,5 58,2	-13,3 -15,5	-40,4- 13,8	41,8 65,0	39,4 44,8	23,2 43,4	0,98- 45,4
Alcohol (g)	1 2	7,9 7,1	14,0 12,2	-0,8 10,6	-5,7- 4,1	13,5 13,2	17,8 15,2	-0,3 -2,3	-6,5- 7,1	4,6 3,8	10,2 10,0	-0,8 19,1	-5,7- 4,1	8,5 6,7	16,4 12,3	-1,5 -19,7	-8,3- 5,3	2,5 2,2	5,0 5,7	-0,3 -13,0	-2,3- 1,8

¶SD= standard deviation; †Diff = mean of second- mean of first administration of QFFQ; ††%=(mean of second- mean of first administration of QFFQ)/(mean QFF1+ mean QFF2)/2*100

Level of significance: *P<0,05; ** = P<0,01

With regard to the entire sample, the mean reported intakes of the second administration of the QFFQ were higher than for the first, with the exception of total carbohydrate and alcohol. For six of the eleven nutrients tested, the differences were not significant ($P>0,05$). The results of the males followed the same pattern as that of the entire sample with the exception of total protein, for which the difference was not significant. The females appeared to perform better with only three of the eleven differences (for total protein, total fat and fibre) showing significant differences between administrations of the QFFQ ($P<0,05$). There were no significant differences between the differences in mean reported intakes of the males and females for any of the nutrients tested ($P>0,05$).

The difference expressed as a percentage of the mean of the two administrations of the QFFQ gives a clearer indication of the agreement between the results. A difference within 10% is considered a good agreement (Wheeler *et al.*, 1994). The mean percentage difference for the 11 nutrients for the entire sample was 8,5 (SD=9,9) with energy, total protein, total carbohydrate and calcium showing differences within 10%. There appeared to be less agreement among the males, with an average percentage difference of 13,0% (SD=13,7%) which was significantly higher than the mean percentage difference for the females (8,0%; SD=6,7%) ($P<0,05$).

There was no consistent pattern of differences between reported mean intakes of nutrients within strata. The reported mean intakes of the middle class urban subjects showed no significant differences between the first and second administrations of the QFFQ. In the upper class urban stratum, the only significant difference was for vitamin C, with the reported mean intake of the second QFFQ being significantly higher than that of the first QFFQ ($P<0,05$). In the farm stratum, the mean reported carbohydrate intake obtained from the first QFFQ was significantly higher than that of the second QFFQ ($P<0,05$). In both the rural and the informal settlement strata, reported mean intakes of four nutrients showed significant differences between QFFQ administrations. In the rural stratum mean intakes were significantly lower on the first administration for total fat, fibre, vitamin A and vitamin C ($P<0,05$). Although differences between mean reported intakes of the other nutrients in the rural stratum were not significant, it is of interest to note that all except for calcium were lower on the first administration than on the second. The informal settlement stratum showed a similar tendency to that of the rural stratum in that the first mean reported intakes for all nutrients were lower than the second with those of total protein, fibre, calcium and iron being significantly different ($P<0,05$). When the differences in mean intakes between strata were compared by the Kruskal-Wallis test, only the differences for vitamin A and vitamin C were statistically significant ($P<0,05$) between the rural and upper class strata and for vitamin C for the farm and informal settlement strata.

Table 6.10: Differences between first and second administration of QFFQ according to age group (N=144)

Age group (years)		15 - 24,9 N=16				25 - 34,9 N=57				35 - 44,9 N=39				45 - 64,9 N=32			
Nutrient		Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI
Energy (kJ)	1	8558	3034	-362	-1529-	8732	2836	811	-207-	8277	2977	546	-787-	7379	2777	-226,2	-1278-
	2	8195	2717	-4,3	2255	9543	3297	8,9	1829	8822	3702	6,4	1879	7606	2753	- 3,0	826
Total protein (g)	1	65,3	25,2	- 0,4	-19,6-	66,8	20,7	9,1	1,9-	61,1	20,2	6,1	-3,0-	57,7	22,5	- 5,7	-14,2-2,8
	2	64,9	23,0	- 0,6	18,8	75,9	26,8	12,8	16,3	67,2	29,5	9,5	15,2	63,4	22,2	- 9,4	
Total carbohydrate (g)	1	298,2	114,8	-37,8	-104-	303,4	111,9	12,7	26,3-	309,0	146,4	- 5,3	-59,9-	270,2	117,4	4,9	-41,2-
	2	260,4	86,3	-13,5	28,3	316,1	113,3	4,1	51,7*	303,7	125,3	1,7	49,3	265,3	108,6	1,8	51,0
Total fat (g)	1	61,6	26,3	7,5	-14,9-	62,6	26,0	13,4	4,5-	52,6	24,0	11,5	0,15-	46,1	21,0	- 5,0	-13,1-
	2	69,1	30,9	11,4	29,9	76,0	33,4	19,3	22,3**	64,1	34,5	19,7	19,7*	51,1	22,6	- 2,5	3,0
Cholesterol (mg)	1	313,9	227,8	3,0	-156-	289,9	167,8	67,8	10,0-	231,1	146,2	60,9	-2,7-	268,4	217,1	-24,2	-104-
	2	316,9	152,2	1,0	162	357,8	202,3	20,9	126*	292,0	189,1	23,3	125	292,6	177,8	- 8,6	55,8
Fibre (g)	1	17,7	6,7	0,1	-4,3-	17,2	7,0	2,2	-0,4-	16,8	7,8	3,5	0,23-	15,1	7,0	- 2,7	-5,3-0,07
	2	17,8	6,8	0,6	4,5	19,4	8,1	12,0	4,8	20,3	9,6	18,4	6,8*	17,8	9,8	-16,4	
Calcium (mg)	1	466,4	278,9	39,4	-221-	479,4	237,1	60,9	-21,1-	480,7	255,1	7,4	-114-	541,4	331,5	83,6	-43,7-
	2	505,8	309,5	8,1	299	540,4	262,4	11,9	143	488,1	256,7	1,5	129	457,8	231,9	16,7	211
Iron (mg)	1	9,0	4,5	- 0,4	-3,1-	9,4	4,3	1,1	-0,36-	7,6	3,0	1,9	0,41-	7,8	3,2	- 1,1	-2,5-
	2	8,6	2,5	-4,5	2,3	10,5	4,3	11,1	2,6	9,6	4,4	22,1	3,3*	8,9	3,9	13,2	0,34
Vitamin A (RE)	1	776,6	653,1	-1,8	-431-	860,5	653,9	-51,1	-183-	724,9	744,9	243,6	-213-	764,0	709,6	-259,4	-559-
	2	774,8	485,7	0,2	428	809,5	436,7	6,1	80,5	968,5	790,9	28,8	274	1023,4	719,8	29,0	40,6
Vitamin C (mg)	1	33,9	19,3	31,9	8,5-	65,0	89,2	- 3,4	-27,4-	44,9	48,5	36,6	14,0-	62,8	106,8	- 0,2	-39,1-
	2	65,9	48,2	63,9	55,3*	61,6	49,3	- 5,4	20,6	75,5	72,1	60,8	58,3**	63,0	60,0	0,3	38,7
Alcohol (g)	1	6,6	13,7	- 1,5	-8,4-5,4	7,7	14,9	- 2,7	-6,8-	6,2	12,1	1,2	-2,7-	7,1	13,1	1,1	-3,15-
	2	5,2	9,5	-25,4		5,1	9,6	-42,2	1,4	7,4	12,7	9,7	5,1	6,0	12,7	16,7	5,35

¶SD= standard deviation; †Diff = mean of second - mean of first administration of QFFQ; ††%=(mean of second- mean of first administration of QFFQ)/(mean QFF1+ mean QFF2)/2*100

Level of significance: *P<0,05; ** = P<0,01; *** P<0,001

The mean reported intakes of subjects in the age group older than 45 years appeared to be the most consistent between the two administrations of the QFFQ. There were no significant differences between the reported mean intakes ($P>0,05$). In the 15 to 24,5-year age group, only vitamin C was significantly lower on the first occasion than on the second ($P<0,05$). The mean reported intakes of total protein, total fat and cholesterol were lower by 9 g, 12 g and 68 mg respectively on the first administration than on the second administration of the QFFQ in the 25 to 34,5-year age group with the differences for total fat and cholesterol being significant ($P<0,05$). Likewise, the reported mean total fat intake of the 35 to 44,9-year age group was 11 g lower when calculated from the first QFFQ than from the second, mean fibre intake was 3,5 g lower, iron 2 mg and vitamin C 35 mg lower. Statistically, there were no significant differences between age groups for any of the differences between mean nutrient intakes reported from the first QFFQ and the second QFFQ ($P>0,05$).

Table 6.11: Mean, standard deviation and difference between means of first and second administrations of the quantitative food frequency questionnaire according to body mass index (N=144)

Body mass index (kg/m ²)													
		< 21 N=44				21 - 26,9 N=46				>=27 N=54			
Nutrient		Mean	SD	+Diff ++%	±95% CI	Mean	SD	+Diff ++%	±95% CI	Mean	SD	+Diff ++%	±95% CI
Energy (kJ)	1	8646	3236	354	-819-	8221	2912	780	-270-	8104	2529	217	-813-
	2	8999	3456	4	1526	9001	3024	9,1	1830	8321	3444	2,6	1247
Total protein (g)	1	63,5	24,7	6,9	-1,7-	60,9	19,4	10,4	2,4-	64,6	20,6	2,5	-5,4-
	2	70,4	20,4	10,3	15,5	71,3	23,6	15,7	18,4*	67,1	27,9	3,8	10,4
Total carbohydrate (g)	1	327	136	-19,0	-64,9-	292	124	3,2	-38-	280	104	1,0	-38,8-
	2	308	113	- 6,0	28,9	295	109	1,1	44,4	281	121	0,4	41,2
Total fat (g)	1	49,8	26,3	12,6	2,8-	56,8	26,8	15,2	5,4-	60,3	22,5	3,5	-5,5-
	2	62,3	36,1	22,5	22,4*	72,0	29,1	23,6	25,0	63,8	32,1	5,6	12,7
Cholesterol (mg)	1	225	152	83,0	15,5-	257	144	93,4	36-	318	218	-15,3	-80,9-
	2	308	219	31,1	151*	351	177	30,8	151**	302	172	- 4,9	50,3
Fibre (g)	1	15,4	7,0	2,3	-4,7-	17,9	7,3	2,0	-0,7-	16,7	6,5	2,6	-0,18-
	2	17,7	7,9	13,9	0,13	19,9	7,9	10,6	4,9	19,3	9,9	14,4	5,4
Calcium (mg)	1	577	326	-41,0	-188-	457	215	45,1	-33,4-	442	234	19,0	-61,4-
	2	536	298	- 7,4	105	502	212	21,1	123	461	240	4,2	99,6
Iron (mg)	1	7,6	3,9	1,5	0,3-2,8*	8,9	4,4	1,6	-0,17-	9,0	3,2	0,5	-0,86-
	2	9,1	3,9	18,0		10,5	4,3	36,8	3,4	9,5	4,0	5,4	1,74
Vitamin A (RE)	1	537	521	223	19,5-	908,8	719	-28,8	-183-	894	727	135	-105-
	2	760	604	34,4	427*	880,0	576	- 3,2	241	1029	697	14,0	375
Vitamin C (mg)	1	31,1	41,1	17,6	4,4-	59,6	65,3	25,5	1,8-	68,4	105	-0,1	-31,4-
	2	48,7	46,6	44,1	30,8*	85,1	67,1	35,2	49,2*	68,3	58,8	-0,2	31,6

Body mass index (kg/m ²)													
		< 21 N=44				21 - 26,9 N=46				≥27 N=54			
Nutrient		Mean	SD	+Diff ++%	±95% CI	Mean	SD	+Diff ++%	±95% CI	Mean	SD	+Diff ++%	±95% CI
Alcohol	1	11,0	15,1	0,1	-4,1-	7,5	16,3	- 1,5	-3,4-	3,5	7,5	- 0,9	-1,9-
(g)	2	11,1	14,8	0,9	4,4	6,0	10,8	-22,2	6,6	2,6	7,5	29,5	3,7

SD= standard deviation; +Diff = mean of second - mean of first administration of QFFQ; ++%=(mean of second- mean of first administration of QFFQ)/(mean QFF1+ mean QFF2)/2*100 Level of significance: *P<0,05; ** = P<0,01; *** P<0,001

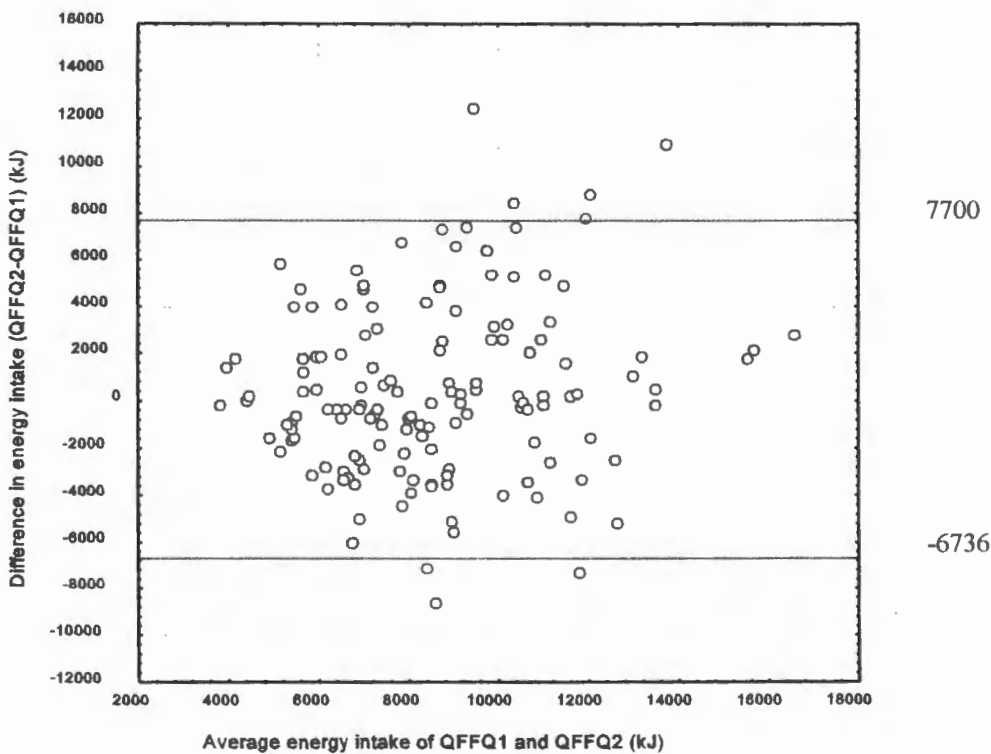
The group of obese subjects (BMI>27) showed no significant differences for any of the nutrient intakes obtained from the first and second administrations of the QFFQ. In contrast, the group of subjects with low BMI's (<21) gave significant differences (P<0,05) for five nutrients, three of which were also significant for the total sample (total fat, cholesterol and iron) and two of which (vitamin A and vitamin C) were not significantly different when the whole sample was compared. The intakes of protein, cholesterol and vitamin C of the group with BMI's within the normal range (21-26,9) were significantly higher on the second administration than on the first administration of the QFFQ (P<0,05) As with the analyses of the whole sample and those of the other subgroups, the mean reported intakes of most nutrients were higher on the second administration of the QFFQ. However, the low BMI group seemed to underestimate intakes of total carbohydrate, fibre and calcium while the mid-range group underestimated vitamin A intake on the second administration, and cholesterol was slightly overestimated in the obese group. Only the mean difference of cholesterol was significantly different among the three groups of BMI (P<0,05) The mean difference in cholesterol intake for the obese group was small (-4,9%) in contrast to the large differences of the low and normal BMI groups (31% difference for each).

6.3.2.3

Agreement between the first and second administrations of the quantitative food frequency questionnaire (Bland-Altman plots)

Bland-Altman plots are scatter diagrams which show the relationship between the difference between the two administrations of the QFFQ and the mean of the two administrations. It is assumed that differences which lies between the mean difference $\pm$ 2SD are in agreement (Bland & Altman, 1986; 1995). Thus, the more observations lying outside the limits of agreement, the poorer the agreement between the two measurements. Another aspect that Bland-Altman plots show is the relationship between the size of the difference and the mean intake of the two administrations of the QFFQ. If proportional bias is present (that is, as the mean intake becomes larger, so does the difference in one direction) the Spearman rank correlation coefficient will be

significant (Bland & Altman, 1986; 1995). The most desirable state is no proportional bias (Spearman rank correlation coefficient small and not significant) and no or very few observations lying outside the limits of agreement (Bland & Altman, 1986; 1995). To illustrate the differences in patterns of agreement, the plots for energy (Figure 6.1) and vitamin C (Figure 6.2) are presented.



QFFQ1 and QFFQ2: First and second administrations of the quantitative food frequency questionnaire

Figure 6.1: Bland-Altman plot for energy (N=144)

Figure 6.1 shows that five subjects fall above the upper limit of agreement (7700kJ) and three subjects below the lower limit of agreement (-6736 kJ). A Spearman rank correlation coefficient of $r=0,136$ ($P>0,05$) indicates that there is no significant proportional bias. From the scatter of the points on the plot, however, there seems to be a tendency for the second QFFQ to give greater values at higher levels of intake than the first QFFQ. By contrast, Figure 6.2 shows the Bland-Altman plot for vitamin C. There is a marked clustering of observations around zero with mean intakes less than 50 mg showing differences between -60 and +80 mg, indicating that at low

intakes differences between administrations are relatively small. However, as the mean intake increases so does the difference in reported intakes between first and second administrations. At mean intakes of greater than 150 mg there is a marked tendency for the repeat QFFQ to give higher intakes than the first, indicating proportional bias.

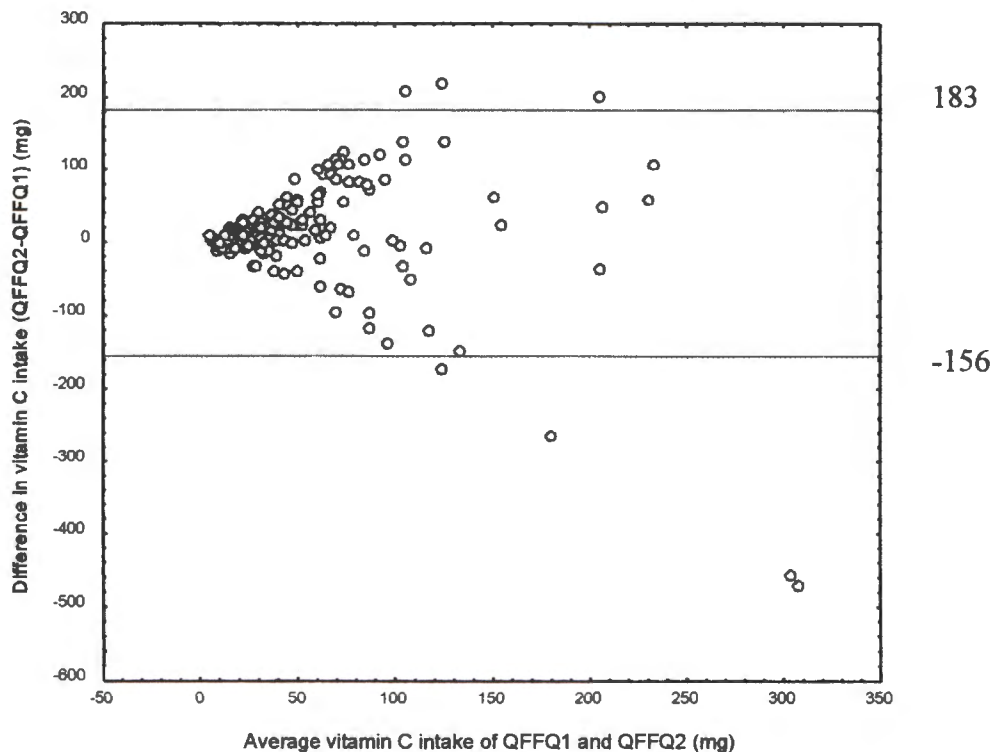


Figure 6.2: Bland-Altman plot for vitamin C (N=144)

Table 6.12 summarises the limits of agreement, the number of observations falling outside the limits of agreement and the Spearman rank correlation coefficient for the other nutrients.

Table 6.12: Summary of agreement between first and second administrations of the quantitative food frequency questionnaire based on the Bland-Altman plots (N=144)

Nutrient	Limits of agreement		Observations outside limits of agreement N	% Agreement	Spearman R	95% CI	s.d./s.m
	Lower	Upper					
Energy (kJ)	-6736	7700	8	94,5	0,136	-0,028-0,293	1,1
Total protein (g)	-47,7	60,8	8	94,5	0,231	0,070-0,380**	1,4
Total carbohydrate (g)	-292	289	8	94,5	-0,068	-0,229-0,097	1,4

Nutrient	Limits of agreement		Observations outside limits of agreement N	% Agreement	Spearman R	95% CI	¶sd/sm
	Lower	Upper					
Total fat (g)	-53,7	74,3	8	94,5	0,261	-0,102-0,407***	1,5
Cholesterol (mg)	-384	487	8	94,5	0,141	-0,023-0,300	1,6
Fibre (g)	-15,6	20,4	9	94	0,146	0,018-0,302***	1,4
Calcium (mg)	-690	720	8	94,5	0,045	-0,119-0,207	1,9
Iron (mg)	-8,4	10,8	10	93,1	0,095	-0,070-0,255	1,6
Vitamin A (RE)	-1373	1603	12	91,7	-0,059	-0,220-0,106	1,4
Vitamin C (mg)	-155,7	182,5	7	95,1	0,221	0,059-0,371**	1,6
Alcohol (g)	-17,8	16,0	21	85,4	0,059	-0,106-0,220	1,3

Level of significance: * $P < 0,05$; ** $P < 0,01$; *** $P < 0,001$; ¶sd/sm=standard deviation of differences ÷ standard deviations of mean. Smaller values indicate better relative agreement.

Although the percentage agreement for all nutrients except alcohol was higher than 90%, three nutrients (protein, total fat and vitamin C) showed definite proportional bias as evidenced by a significant Spearman rank correlation coefficient. Thus, for these nutrients, differences between reported intakes on the two administrations of the QFFQ increased as the reported intakes increased. The Bland-Altman plot for alcohol (Figure 6.3) shows an interesting tendency. As can be seen from Table 6.12, despite a weak non-significant Spearman rank correlation ($r=0,06$), the agreement between administrations is weak. The clustering of 20 subjects around a difference of zero could be due to the fact some subjects reported no or very low alcohol intakes consistently on both administrations of the QFFQ. As the intakes increase, the differences increase positively and negatively to very similar extents, thus resulting in a weak correlation.

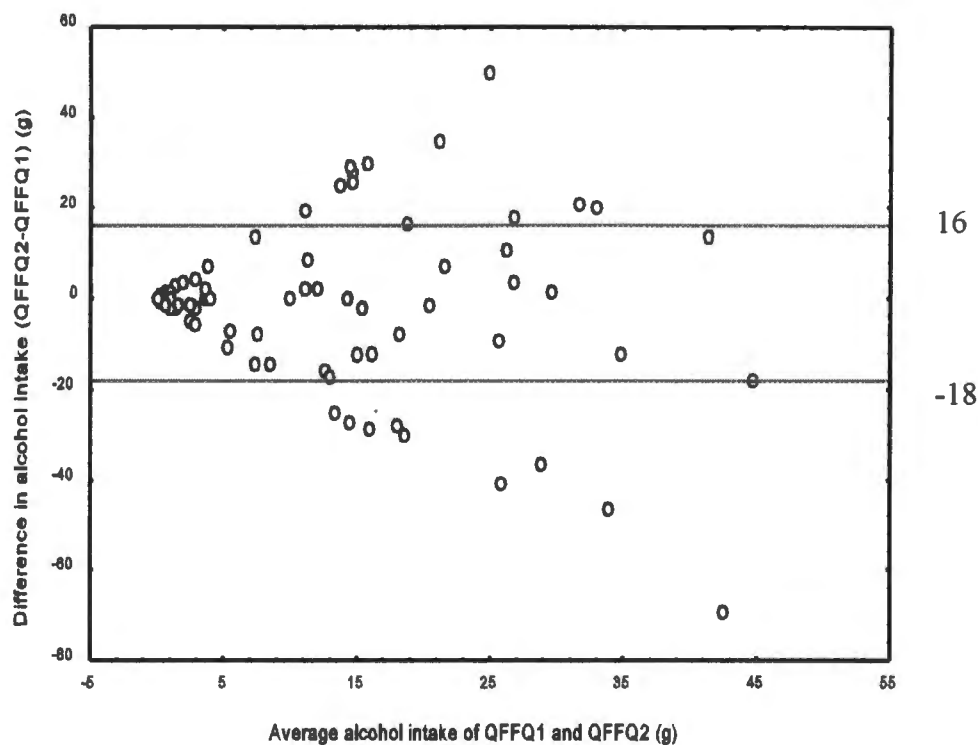


Figure 6.3: Bland-Altman plot for alcohol

6.3.2.4 Comparison of distribution in quintiles between administrations of the quantitative food frequency questionnaire

The previous statistical analyses have compared the results of individual subjects between the first and second administrations of the QFFQ. Another way of determining reproducibility is to compare the positions of subjects within the distribution on the two administrations of the QFFQ. The distribution for each nutrient was divided into quintiles and the number of subjects falling into the same and adjacent quintiles on each administration determined. The cumulative percentage of subjects falling within the same and adjacent quintiles for the entire sample and for males and females are given in Table 6.13.

Table 6.13: Classification of subjects into the same and adjacent quintiles of the distribution for the two administrations of the QFFQ (N=144)

Nutrient	Total sample(N=144)				Males (N=45)				Females (N=99)			
	Cumulative %				Cumulative %				Cumulative %			
	S	±1	±2	±3	S	±1	±2	±3	S	±1	±2	±3
Energy	22	70	93	99	27	70	90	96	20	70	94	99
Protein	30	82	96	100	31	78	96	100	29	84	96	100
Carbohydrate	33	76	96	97	18	71	93	93	16	77	97	98
Fat	31	77	96	98	27	82	93	95	33	75	97	99
Cholesterol	49	81	94	95	36	85	98	100	20	78	90	91
Fibre	38	84	99	99	33	84	97	97	39	84	99	100
Calcium	31	70	87	93	27	67	85	94	33	73	90	94
Iron	39	81	96	96	42	76	92	92	37	83	97	97
Vitamin A	48	85	93	94	51	82	86	88	46	86	96	97
Vitamin C	84	97	100	100	38	84	98	100	83	97	100	100
Alcohol	75	88	98	99	54	76	94	96	84	93	99	100

S=classified into the same quintile; ±1=adjacent quintiles; ±2= two quintiles difference; ±3= 3 quintiles difference

More than 70% of the subjects were in similar positions within the distribution for all nutrients tested on both administrations of the QFFQ. The distributions of vitamin C and alcohol were the most similar on both occasions with 84% and 75% of the sample being classified into the same quintile. The distribution of energy showed the least agreement between administrations with only 22% of the sample being classified into the same quintile and 48% into adjacent quintiles. There were no significant differences between the percentages of males and females classified into similar quintiles for any of the nutrients except for alcohol ($P<0,01$). The high percentage of females classified into the same quintile (84%) can be explained by the fact that the majority (54%) of the females did not consume alcohol and therefore would not have reported intakes on either occasion.

6.3.3 Comparison of food groups between first and second administrations of the quantitative food frequency questionnaire

6.3.3.1 Spearman rank correlation coefficients between first and second administrations for food groups

As described in the methods section, dietary intakes were expressed in terms of food groups as well as in terms of nutrients. Spearman rank correlation coefficients were calculated for each food group for the sample as a whole and then for the various subgroups. Since there were very few significant differences among the various groups of BMI, food groups are not reported, for these categories.

Table 6.14: Spearman rank correlation coefficients for food groups between first and second administrations of the quantitative food frequency questionnaire (N=144)

Food group	Entire sample N=144		Males N=45		Females N=99	
	ρ R	95% CI	ρ R	95% CI	ρ R	95% CI
Milk	0,258	0,099-0,405**	0,238	-0,060-0,0497	0,261	0,067-0,436**
Meat	0,536	0,408-0,643***	0,719	0,539-0,836***	0,437	0,262-0,584***
Fish	0,312	0,156-0,452***	0,447	0,177-0,655***	0,245	0,050-0,422*
Legumes	-0,020	0,183-0,144	-0,045	-0,334-0,252	-0,027	0,228-0,171
Eggs	0,337	0,184-0,474***	0,181	-0,119-0,451	0,401	0,221-0,555***
Fruit	0,352	0,200-0,488***	0,355	0,203-0,490*	0,353	0,167-0,515***
Vegetables	0,451	0,310-0,572***	0,416	0,139-0,632***	0,425	0,248-0,574***
Maize meal	0,452	0,311-0,572***	0,625	0,406-0,776***	0,341	0,154-0,504***
Rice	0,332	0,200-0,488***	0,599	0,371-0,759***	0,189	-0,009-0,373
Samp	0,257	0,098-0,404**	0,320	0,029-0,561*	0,241	0,046-0,419*
Bread	0,289	0,132-0,432***	0,345	0,057-0,580*	0,233	0,037-0,411*
Other cereals	0,269	0,110-0,414***	0,180	0,120-0,450	0,252	0,057-0,428*
Fat	0,321	0,166-0,460***	0,404	0,125-0,624**	0,250	0,055-0,429*
Sugar	0,246	0,086-0,394**	0,296	0,003-0,542*	0,229	0,033-0,408*

ρ R: Spearman rank correlation coefficient; Level of significance: *P<0,05; **P<0,01; *** P<0,001

95% CI: 95% confidence interval

All correlations between the two administrations of the QFFQ were statistically significant for the sample as a whole, except for that for legumes. Interestingly, the correlation for the milk group was significant in contrast to that of calcium which was not significant (Table 6.1). The Spearman rank correlation coefficients for males for three food groups (meat, maize meal and rice) were significantly higher than those for the females ($P < 0.05$). There were no significant differences between correlation coefficients for any of the other food groups ($P > 0.05$).

Table 6.15: Spearman rank correlation coefficients for food groups between first and second administrations of the quantitative food frequency questionnaire according to stratum of urbanisation (N=144)

Nutrient	Rural N=34		Farm N=20		Informal settlement N=28		Middle class urban N=32		Upper class urban N=30	
	¶R	95% CI	¶R	95% CI	¶R	95% CI	¶R	95% CI	¶R	95% CI
Milk	0.408	0.081-0.656*	-0.450	-0.744-0.01*	0.312	-0.069-0.614	0.544	0.241-0.750**	0.148	0.224-0.483
Meat	0.236	-0.111-0.532	0.394	-0.059-0.712	0.321	-0.059-0.620	0.212	-0.148-0.522	0.312	-0.054-0.604
Fish	0.105	-0.242-0.428	0.168	-0.297-0.568	0.532	0.198-0.755**	-0.067	-0.406-0.288	0.373	0.147-0.646*
Legumes	0.012	-0.328-0.349	-0.236	-0.614-0.231	-0.12	-0.475-0.261	0.032	-0.320-0.376	0.156	-0.216-0.489
Eggs	0.514	0.213-0.726**	0.389	-0.065-0.709	0.180	-0.207-0.518	0.209	-0.151-0.520	0.102	-0.268-0.446
Fruit	-0.07	-0.395-0.278	0.077	-0.378-0.502	0.231	-0.155-0.556	0.249	-0.109-0.550	0.391	0.036-0.659*
Vegetables	0.302	-0.092-0.545	0.076	-0.379-0.502	0.672	0.399-0.836***	0.335	-0.016-0.612	0.325	-0.040-0.613
Maize meal	0.254	-0.285-0.389	0.254	0.212-0.626	0.172	0.215-0.512	0.388	0.454-0.649*	0.329	-0.036-0.616
Rice	0.059	-0.285-0.389	0.548	0.139-0.797*	0.299	-0.083-0.605	0.312	-0.041-0.596	0.132	-0.240-0.470
Samp	0.176	-0.172-0.485	-0.022	-0.460-0.425	0.384	0.013-0.662*	0.044	-0.309-0.387	0.386	0.030-0.655*
Bread	0.105	-0.242-0.428	0.170	0.295-0.570	0.362	-0.013-0.648*	0.297	-0.058-0.585	0.125	-0.246-0.464
Other cereals	0.134	0.214-0.452	0.033	-0.416-0.469	-0.03	-0.398-0.348	0.376	0.031-0.641*	0.506	0.178-0.733**
Fat	0.491	0.183-0.771**	0.097	-0.361-0.517	0.496	0.151-0.733**	-0.127	-0.456-0.232	-0.09	-0.430-0.287
Sugar	0.375	0.042-0.633*	0.221	0.246-0.604	0.296	-0.087-0.603	0.168	-0.192-0.488	0.193	-0.180-0.517

¶R=Spearman rank correlation coefficient; 95% CI: 95% confidence interval

Level of significance: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

The most significant differences in Spearman rank correlation coefficients can be seen between the negative correlation for the milk intake of the farm worker stratum and that of the other four strata ($P < 0.05$). The reported fat intakes of both the middle class and upper class urban strata showed weak negative correlations between the first and second administrations of the QFFQ, which were significantly lower than the Spearman rank correlation coefficients of the rural and informal settlement strata ($P < 0.05$) but not significantly different from that of the farm worker

stratum ($P>0,05$). The only other significant difference occurred between the very weak negative correlation coefficient for other cereals for the informal settlement stratum and the strong positive correlation coefficient for the upper class urban stratum ($P<0,05$).

Table 6.16: Spearman rank correlation coefficients for food groups between first and second administrations of the quantitative food frequency questionnaire according to age groups (N=144)

Food group	Age Group (years)							
	15-24,9 N=16		25 - 34,9 N=57		35 - 44,9 N=39		45 - 64,5 N=32	
	¶R	95% CI	¶R	95% CI	¶R	95% CI	¶R	95% CI
Milk	0,090	-0,425-0,561	0,250	-0,110-0,479	0,226	-0,096-0,505	0,401	0,061-0,658*
Meat	-0,012	-0,505-0,487	0,573	0,367-0,725***	0,738	0,551-0,855***	0,332	-0,019-0,610
Fish	0,331	-0,197-0,710	0,333	0,079-0,546*	0,325	0,011-0,581*	0,263	-0,094-0,560
Legumes	-0,297	-0,691-0,233	-0,046	-0,303-0,217	-0,067	-0,375-0,254	0,065	-0,290-0,405
Eggs	0,254	-0,277-0,666	0,270	0,010-0,496*	0,261	-0,059-0,533	0,576	0,284-0,77***
Fruit	0,576	0,112-0,834*	0,312	0,056-0,530*	0,403	0,100-0,637	0,233	-0,126-0,538
Vegetables	0,609	0,162-0,849*	0,276	0,017-0,501*	0,539	0,269-0,730***	0,531	0,224-0,742**
Maize meal	-0,427	-0,762-0,087	0,398	0,153-0,597**	0,480	0,194-0,691**	0,598	0,315-0,78***
Rice	-0,141	-0,595-0,381	0,400	0,156-0,589**	0,243	-0,079-0,519	0,625	0,353-0,80***
Samp	0,106	-0,411-0,572	0,342	0,089-0,553**	0,077	-0,244-0,383	0,304	-0,050-0,590
Bread	0,372	-0,152-0,733	0,255	-0,006-0,483	0,051	-0,269-0,361	0,513	0,200-0,731**
Other cereals	-0,333	-0,195-0,711	0,504	0,280-0,676***	0,206	-0,117-0,490	0,163	-0,197-0,484
Fat	0,394	0,126-0,744	0,196	-0,068-0,434	0,289	-0,029-0,554	0,446	0,115-0,688*
Sugar	0,357	-0,169-0,724	0,319	0,064-0,535*	0,230	-0,090-0,509	0,074	-0,282-0,412

¶R=Spearman rank correlation coefficient; 95% CI: 95% confidence interval

Level of significance: * $P<0,05$; ** $P<0,01$; *** $P<0,001$

Similarly to the correlations of the nutrients, the youngest age group showed only two significant Spearman rank correlation coefficients (for fruit and vegetables) ($P<0,05$). There was a moderate, negative correlation between administrations of the QFFQ for maize meal for the youngest age group in contrast to the other age groups which showed moderate to strong positive correlations ($P<0,001$). Other significant differences between Spearman rank correlation coefficients were found for meat between the two younger age groups ($P<0,05$) and between the 15 to 24,9 year and the 35 to 44,9-year age group ($P<0,01$); for cereals between the younger two age groups ($P<0,01$) and between the older two age groups for meat and bread ($P<0,05$)

6.3.3.2

Paired t-tests between first and second administrations of the quantitative food frequency questionnaire for food groups

The mean differences between reported food intakes obtained from the first and second administrations of the QFFQ were compared similarly to nutrient intakes. The means and standard deviations of the food intakes as well as the mean and mean percentage differences and 95% confidence intervals for the sample as a whole and males and females are given in Table 6.17, for the strata of urbanisation in Table 6.18 and for age groups in Table 6.19. Since there were few significant differences among nutrients when the sample was divided into groups according to BMI, food group differences were not compared in relation to BMI.

Table 6.17: Mean, standard deviation and differences for food groups between first and second administrations of the quantitative food frequency questionnaire (N=144)

		Entire sample N=144				Males N=45				Females N=99			
Food group		Mean	SD	+Diff ++%	95% CI	Mean	SD	+Diff ++%	95% CI	Mean	SD	+Diff ++%	95% CI
Milk (g)	1 2	221,8 193,9	211,7 168,1	- 27,9 -13,4	-69,2- 13,4	253,4 214,9	228 189	-38,6 -16,5	-12,0- 42,5	207,7 184,6	203 158	-23,2 -11,8	-25,2- 71,6
Meat (g)	1 2	87,7 106,2	67,4 70,7	18,5 19,1	7,2- 29,8**	111,0 87,0	80,2 77,4	19,3 24,9	-1,7- 40,3*	86,6 104,7	61,3 67,9	18,1 18,9	4,5- 31,7**
Fish (g)	1 2	12,5 17,5	21,2 20,5	5,0 33,3	1,5- 8,5**	16,5 20,5	33,5 23,4	1,1 3,9	-5,6- 7,8	10,7 17,4	12,2 19,3	6,7 47,7	2,6- 10,8**
Legumes (g)	1 2	23,0 43,4	31,9 48,3	20,5 61,6	10,7- 30,3***	12,1 42,8	15,8 49,3	30,7 111,8	14,8- 46,6***	27,8 43,7	35,9 48,2	15,9 44,5	3,5- 28,3**
Eggs (g)	1 2	28,2 32,2	35,2 31,6	4,1 13,6	-3,1- 11,3	29,0 41,0	33,0 41,8	12,0 34,3	-3,4- 27,4	27,8 28,3	36,3 25,2	0,5 1,8	-7,4- 8,4
Fruit (g)	1 2	124,6 144,1	156,8 134,1	19,5 14,5	-12,3- 26,7	101,5 164,7	131 166	63,2 47,5	16,0- 110,0*	134,8 135,0	166,6 117,0	0,2 0,1	-33,3- 33,7
Vegetables (g)	1 2	93,5 111,2	63,4 77,8	17,7 17,3	5,3- 30,1	80,9 95,9	65,6 78,1	15,0 17,0	-10,7- 40,7	99,1 118,0	62,4 77,1	18,9 17,4	4,7- 33,1**
Maize meal (g)	1 2	122,5 93,4	108,0 77,0	-29,1 -27,0	-45,6- -12,6***	166,9 122,9	136 97	-44,0 -30,4	10,1- 77,9*	102,8 80,3	86,5 62,2	-22,5 -24,6	-41,1- -3,9*
Rice (g)	1 2	37,1 37,0	52,2 41,5	-0,1 -0,4	-10,0- 9,8	40,6 43,0	78,0 47,6	2,4 5,7	-24,3- 29,0	35,5 34,4	35,6 38,4	-1,1 -3,1	-9,4- 7,2
Samp (g)	1 2	28,1 29,5	43,9 45,3	-0,3 -1,1	-8,2- 8,8	21,5 31,9	31,2 40,0	10,4 39,0	-4,3- 25,1	31,0 28,4	48,4 47,5	- 2,6 - 8,8	-13,1- 7,9

		Entire sample N=144				Males N=45				Females N=99			
Food group		Mean	SD	+Diff ++%	95% CI	Mean	SD	+Diff ++%	95% CI	Mean	SD	+Diff ++%	95% CI
Bread (g)	1 2	86,6 100,0	79,4 83,2	13,4 14,4	-3,2- 30,0	98,4 114,0	1093 97,1	15,5 14,6	-24,3- 55,3	81,3 93,8	61,7 76,0	12,5 14,3	-4,25- 29,3
Cereals (g)	1 2	42,7 33,3	97,3 57,1	- 9,4 -24,7	-28,2- 9,4	41,8 23,3	116 41,9	-18,5 -56,8	-17,9- 54,9	43,1 37,8	88,6 62,3	- 5,3 -13,1	-27,5- 16,9
Fat (g)	1 2	13,0 15,2	14,3 21,2	2,2 15,6	-1,8- 6,2	12,1 14,3	17,6 23,3	2,2 16,7	-5,9- 10,3	13,4 15,6	12,6 20,3	2,3 15,9	-2,3- 6,9
Sugar (g)	1 2	33,3 35,8	42,5 37,2	2,5 7,2	-6,3- 11,3	29,0 33,2	34,5 34,6	4,3 13,8	-9,0- 17,5	35,2 36,9	45,7 38,4	1,7 4,7	-9,6-13,0

+Diff=mean intake of second - mean intake of first administration of QFFQ; ++% =((mean of second- mean of first administration of QFFQ)/(mean QFF1+ meanQFF2)/2)*100; SD: standard deviation

Level of significance: *P<0,05; ** P<0,01; *** P<0,001; 95% CI: 95% confidence interval

Dealing with the entire sample, 10 of the 14 food groups showed no significant differences in reported intakes between administrations of the QFFQ ($P>0,05$). Significant differences were obtained for meat ($P<0,01$), fish ($P<0,01$), legumes ($P<0,001$) and maize meal ($P<0,001$). Percentage differences ranged from 0,4% for rice to 62% for legumes, with only four food groups having a percentage difference of less than 10% (rice, samp and sugar).

The pattern of differences for the males was similar to that of the total sample, except that the mean reported fruit intake on the second administration of the QFFQ was significantly higher than on the first administration of the QFFQ ($P<0,05$) and the difference in reported mean intakes of fish was small and not significant ($P>0,05$). The females showed an interesting contrast to the males in that, while differences were significant for meat, fish, legumes ($P<0,01$) and maize meal ($P<0,05$) (same as the total sample), there was only 0,1% difference in the mean reported fruit intakes ($P>0,05$) but the difference in mean reported vegetable intakes was significant at 17,4% ($P<0,01$). The reproducibility of the QFFQ appeared to be no different for males and females as no significant differences were found among the mean differences of any of the food groups ($P>0,05$).

With reference to the strata of urbanisation (Table 6.18) there appeared to be an improvement in reproducibility with a higher level of urbanisation. There were no significant differences for the upper class urban stratum and only two significant differences (for legumes $P<0,001$ and milk $P<0,05$) in the middle class urban stratum. In contrast, there were significant differences for six of the 14 food groups for the rural stratum (milk, meat, legumes, fruit, vegetable and maize meal: $P<0,001$), four in the farm stratum (meat, maize meal, rice and fat; $P<0,01$) and two in the informal settlement stratum (meat and vegetable ; $P<0,01$). Likewise, bread and sugar are the only food groups to have had percentage differences of less than 10% for the rural and farm strata respectively; in the informal settlement stratum, the milk and fat groups had percentage differences less than 10%; the middle class urban stratum had five food groups with differences of less than 10% (meat, eggs, fruit, rice and bread) and the upper class urban stratum had six food groups with differences of less than 10% (meat, fruit, vegetables, rice, fat and sugar). The difference in mean reported intakes for fruit was significantly greater in the rural stratum than any of the other strata ($P<0,05$).

Table 6.18: Mean, standard deviation and differences for food groups between first and second administrations of the quantitative food frequency questionnaire according to stratum of urbanisation (N=144)

		Rural N=34				Farm N=20				Informal Settlement N=28				Middle class urban N=32				Upper class urban N=30			
Nutrient		Mean	SD	Diff %	95% CI	Mean	SD	Diff	95% CI	Mean	SD	Diff %	95% CI	Mean	SD	Diff %	95% CI	Mean	SD	Diff %	95% CI
Milk (g)	1 2	245,7 136,4	211 163	-109 - 57	-187- 31,**	475,4 320,2	321 243	-155 - 39	-378- 67,4	158,8 158,0	152 106	- 0,8 - 0,5	-67,2- 65,6	146,2 191,2	104 130	45,0 26,7	2,5- 87,5*	166,4 209,5	104 159	43,1 22,9	-22,7- 109
Meat (g)	1 2	53,8 89,8	52,4 66,2	36,1 50,3	17,8- 54**	22,1 36,6	18,1 26,7	14,5 49,4	1,1- 27,9**	85,7 116,3	42,6 70,9	30,5 30,2	6,5- 54,5*	111,0 125,0	60,0 65,8	14,0 6,5	-12,0- 40	146,0 141,3	71,1 66,8	- 4,8 - 3,3	-37,4- 27,8
Fish (g)	1 2	16,5 19,9	38,2 25,7	3,4 18,7	-5,6- 12,4	4,2 5,2	6,4 8,2	1,0 21,3	-4,0- 6,0	11,7 16,1	14,6 15,8	4,4 31,7	-1,8- 10,6	10,7 18,4	10,0 20,4	7,7 52,9	-1,0- 16,4	16,3 23,3	13,3 21,6	7,0 35,4	-1,2- 15,2
Legumes(g)	1 2	12,1 38,5	19,4 42,3	26,5 105	9,7- 43**	28,4 34,2	48,8 50,0	5,8 18,5	-30,9- 42,5	29,1 44,9	35,6 44,4	15,8 42,7	-5,1- 36,7	25,8 63,2	31,9 61,5	43,3 97,0	17,3- 69***	22,6 26,2	23,4 28,6	3,7 15,2	-10,6- 18,0
Eggs (g)	1 2	24,5 34,1	31,7 34,0	9,6 32,8	-4,9- 24,1	8,8 15,9	18,8 33,2	7,2 58,3	-10,5- 24,9	39,4 35,5	46,4 33,3	- 3,9 -10,4	-17,0- 24,8	33,0 33,9	39,5 27,7	0,9 2,7	-15,3- 17,1	29,5 36,1	25,5 28,8	6,7 20,4	-7,9- 21,2
Fruit (g)	1 2	30,0 159,8	48,3 150	129 137	77- 182***	21,5 15,4	33,2 16,3	- 6,2 -33,6	-23,1- 10,7	175,5 139,8	143 127	-35,6 -22,6	-98,6- 27,4	163,5 169,8	205 134	6,3 3,8	-64,9- 77,5	208,4 189,3	154 119	-19,1 - 9,6	-77,9- 39,7
Vegetables(g)	1 2	66,3 101,0	50,9 83,7	34,5 41,2	5,9- 63,1*	54,6 70,1	33,4 64,1	15,5 -16,6	-16,6- 47,6	97,1 131,6	60,2 83,8	34,6 30,3	10,6- 58,9**	110,1 122,3	65,3 69,0	12,3 10,6	-13,8- 38,4	128,2 118,9	70,1 75,7	- 9,3 - 7,5	-40,1- 21,5
Maize meal (g)	1 2	154,0 106,4	96,4 92,6	-47,6 -36,6	6,4- 88,8*	256,1 150,9	134 79,0	-105 -51,7	-160- 50,1**	106,8 93,1	82,4 67,7	-13,6 -13,7	-25,1- 52,3	102,6 88,7	9,9 68,2	-13,9 -14,5	-41,0- 13,2	34,9 46,1	37,6 38,3	11,2 27,7	-7,5- 29,9
Rice (g)	1 2	21,2 26,0	22,9 19,2	4,5 19,1	-6,1- 15,1	7,3 16,0	8,5 12,4	8,7 74,7	3,4- 14,0**	44,0 34,4	35,8 22,1	- 9,5 -24,2	-25,3- 6,3	50,3 52,4	86,4 57,5	2,1 4,1	-33,7- 37,9	53,7 49,2	46,0 55,4	- 4,5 - 8,7	-28,7- 19,7
Samp (g)	1 2	22,7 28,4	32,5 40,3	5,8 12,9	-12,9- 24,5	18,2 21,3	22,5 17,7	3,1 15,7	-10,1- 16,3	25,7 28,7	40,0 30,7	3,0 11,0	-14,6- 20,3	37,7 47,7	57,9 76,7	9,9 23,2	-14,4- 34,2	32,6 17,4	51,4 17,3	-15,2 -60,8	-32,9- 2,5

		Rural N=34				Farm N=20				Informal Settlement N=28				Middle class urban N=32				Upper class urban N=30			
Nutrient		Mean	SD	Diff %	95% CI	Mean	SD	Diff	95% CI	Mean	SD	Diff %	95% CI	Mean	SD	Diff %	95% CI	Mean	SD	Diff %	95% CI
Bread (g)	1	103,1	114	4,7	-45,3-	36,6	33,9	13,7	-10,1-	92,4	80,8	-9,7	-37,1-	97,6	54,9	2,5	-36,1-	84,6	64,1	31,4	-1,83-
	2	107,8	89,2	4,5	54,3	50,3	43,0	31,5	37,5	82,6	66,9	-13,1	17,7	123,3	94,8	2,3	41,1	115,9	85,0	31,3	64,6
Cereals (g)	1	67,2	141	-38,0	-14,1-	3,5	7,9	10,6	-22,2-	64,9	141	-19,0	-88,8-	20,6	26,1	12,2	-7,2-	44,6	49,7	-5,2	-27,5-
	2	29,3	45,7	-78,5	89,9	14,1	26,0	20,5	23,4	45,8	90,7	-34,3	50,8	32,8	49,4	45,7	31,6	39,4	49,7	-12,3	17,1
Fat (g)	1	10,9	9,1	1,4	-2,7-	5,8	7,1	-1,4	-11,0-	12,2	10,1	2,2	-4,0-	15,0	17,2	5,9	-4,9-	18,6	19,7	1,7	-12,3-
	2	12,4	14,5	12,0	5,5	4,4	5,1	-27,5	-3,4*	14,4	17,1	4,0	8,4	20,8	24,1	23,2	16,7	20,3	30,0	8,7	15,7
Sugar (g)	1	41,1	68,4	-9,2	-33,8-	32,8	34,1	0,2	-18,6-	36,8	33,0	12,1	-7,8-	29,4	30,0	7,9	-9,7-	25,8	28,1	2,2	-14,6-
	2	31,9	27,7	-25,2	15,4	33,0	28,8	0,6	19,0	48,9	47,8	28,2	32,0	37,3	42,1	23,7	25,5	28,0	33,4	8,2	19,0

SD=standard deviation; Diff=mean intake of second-mean intake of first administration of QFFQ; %=((mean of second- mean of first administration of QFFQ)/(mean QFF1+ mean QFF2)/2)*100; Level of significance: *P<0,05; ** P<0,01; *** P<0,001; 95%CI: 95% confidence interval

Table 6.19: Mean, standard deviation and differences for food groups between first and second administrations of the quantitative food frequency questionnaire according to age groups (N=144).

		Age groups (years)															
		15 - 24,9 N=16				25 - 34,9 N=57				35 - 44,9 N=39				45 - 64,9 N=32			
Food group		Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI
Milk (g)	1	201,2	227	15,2	-159-	183,3	144,3	4,1	-41,2-	238,2	216,6	-35,2	-127-	282,6	284,1	-99,7	-4,0-203
	2	216,4	213	7,3	189	187,4	152,8	2,2	49,4	203,0	190,5	-16,0	56,5	182,9	144,6	-42,8	
Meat (g)	1	89,3	50,6	13,2	-25,7-	108,9	76,7	9,9	-10,5-	76,5	63,3	25,8	6,2-	62,2	49,6	27,7	5,9-
	2	102,5	50,5	13,8	52,1	118,8	73,4	8,7	30,3	102,3	83,1	28,9	45,4**	89,9	54,4	36,4	49,5**
Fish (g)	1	14,5	19,4	- 1,3	-14,9-	16,8	29,7	5,2	-11,1-	10,7	11,4	1,5	-3,4-	5,7	6,6	12,3	5,7-
	2	13,2	17,0	- 9,4	12,3	22,0	25,0	26,8	11,5	12,2	15,5	13,1	6,4	18,0	17,2	103,8	18,9**
Legumes (g)	1	28,1	34,0	7,4	-20,7-	23,5	33,8	25,7	8,3-	23,6	31,2	17,5	-2,7-	18,5	29,0	21,5	3,8-39,2*
	2	35,5	29,9	23,3	35,5	49,2	51,5	70,7	43,1**	41,1	50,9	54,1	37,7	40,0	47,6	73,5	
Eggs (g)	1	35,9	50,5	1,5	-31,2-	28,5	31,8	10,5	-1,5-	22,5	23,5	1,5	-7,9-	30,6	44,0	- 3,1	-20,0-13,8
	2	37,4	27,5	4,1	34,2	39,0	37,5	31,1	22,5	23,9	21,2	6,5	10,9	27,6	30,8	-10,7	
Fruit (g)	1	154,1	154	-13,7	-82,4-	144,5	172,2	- 9,2	-50,5-	98,5	133,7	77,9	18,6-	105,6	155,0	16,1	-46,1-78,3
	2	140,4	111	9,3	55,0	135,3	118,1	- 6,6	32,1	176,4	161,4	56,7	137**	121,7	133,6	14,2	
Vegetables(g)	1	87,2	56,9	13,7	-15,3-	101,6	55,8	- 5,7	-25,4-	98,5	72,7	45,5	18,2-	75,5	67,8	27,8	4,3-51,3*
	2	100,9	46,2	14,6	42,7	95,9	65,3	- 5,8	14,0	144,0	93,8	37,5	72,8**	103,3	80,7	31,1	
Maize meal (g)	1	102,5	71,9	-28,1	-74,5-	98,4	92,5	- 6,0	-29,3-	150,9	126,8	-50,3	-85,3-	141,4	116,5	-45,5	-86,2-4,8*
	2	74,4	30,5	-31,8	18,3	92,4	76,0	- 6,3	17,3	100,6	90,4	-40,0	-15,3**	95,9	78,7	-38,3	
Rice (g)	1	49,4	37,2	-16,6	-40,2-	51,7	73,6	- 6,5	-29,0-	24,8	23,0	2,9	-6,9-	19,2	20,0	16,5	5,9-
	2	32,8	22,8	-40,4	7,0	45,2	56,3	-13,4	16,0	27,7	24,4	11,0	12,7	35,7	30,9	60,1	27,1**

Food group		Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI	Mean	¶SD	†Diff ††%	95% CI
Samp (g)	1	22,8	29,4	- 0,1	-21,0-	35,2	52,2	- 3,2	-17,8-	30,0	48,5	1,7	-18,7-	15,2	18,3	10,3	-1,5-22,1
	2	22,7	26,4	- 0,4	20,8	32,0	57,7	- 9,5	11,4	31,7	40,6	3,8	22,7	25,4	31,4	24,9	
Bread (g)	1	109,2	75,0	-23,2	-60,6	94,1	72,7	38,4	8,15-	81,9	105,7	- 8,3	-43,1-	66,9	46,7	13,8	-10,5-38,1
	2	86,0	67,0	-23,8	14,6	135,4	102,5	33,5	68,6*	73,6	46,6	-10,7	26,5	80,7	69,1	23,8	
Cereals (g)	1	34,9	85,7	-17,6	-66,1-	38,7	81,8	- 8,8	-33,2-	32,5	67,5	4,3	-25,9-	66,7	148,5	-23,2	-87,0-40,6
	2	17,3	23,8	-67,4	30,9	29,9	42,5	-25,7	15,6	36,8	68,1	12,4	34,4	43,5	74,8	-42,1	
Fat (g)	1	11,8	8,5	- 1,0	-5,7-	16,8	19,3	3,3	-5,3-	11,4	9,8	2,5	-4,9-	8,5	8,1	1,8	-1,5-5,1
	2	10,8	8,3	- 8,8	3,7	20,1	26,8	17,9	11,9	13,9	21,2	19,8	9,9	10,3	9,5	19,1	
Sugar (g)	1	38,4	49,9	-2,2	-29,1-	33,1	29,8	1,9	-9,4-	38,6	61,1	0,4	-24,4-	24,2	28,1	8,6	-4,7-21,9
	2	36,2	34,9	-5,9	24,7	35,0	39,3	5,6	13,2	39,0	42,9	1,3	25,2	32,8	26,5	30,2	

¶SD=standard deviation; †Diff=mean intake of second -mean intake of first administration of QFFQ

Level of significance: *P<0,05; ** P<0,01; *** P<0,001; 95% CI: 95% confidence interval

From the number of significant differences between intakes of the first and second administrations of the QFFQ, it appears that age may have an effect on reproducibility. The youngest age group (15 to 24,9 years of age) showed no significant differences with the smallest percentage differences of 0,4% for samp, 4% for eggs and 6% for sugar and the largest differences for rice (40%) and other cereals (67%). The milk, fish, fruit, samp, fat and sugar groups all showed differences of less than 10%. The differences for the age group 25 to 34,9 years of age were similar except that the reported mean intakes of legumes and bread were significantly higher on the second than on the first administration of the QFFQ. Of the food groups with less than 10% difference between the two administrations, four were the same as for the youngest age group (milk, fruit, samp and sugar). The differences for fish and fat were greater than 10%, but the difference for the vegetables was only 6%. The number of significant differences increased in the older age groups with four significant differences in the 35 to 44,9 year age group (meat, fruit, vegetables and maize meal) and six significant differences in the age group older than 45 years of age (meat, fish, legumes, vegetables, maize meal, rice). It is noteworthy that several of the food groups with small differences in the younger age groups had significant differences in the older groups (fish, fruit, and vegetables). Only three food groups showed differences of less than 10% in the age group 35-44,9 years of age (eggs, samp and sugar) while no food group showed a percentage difference of less than 10% in the oldest age group.

Although the number of significant differences increased with age group, comparison of the mean differences between administrations of the QFFQ across age groups gave no significant differences ($P > 0,05$).

6.3.3.3 Agreement between first and second administrations of the quantitative food frequency questionnaire for food groups (Bland-Altman plots)

In order to determine the extent of agreement between reported food intakes according to food groups between administrations of the QFFQ, the Bland-Altman method (Bland & Altman, 1986; 1995) was applied to the food group data. The plot for maize meal is presented because maize meal is the food most frequently consumed and in the largest amounts (Figure 6.4). This plot demonstrates there is poor agreement between the results of the two administrations of the QFFQ. There is a significant negative correlation between the difference and mean of the intakes ($r = -0,35$;

P<0,01) indicating that as the mean intakes become larger, so do the differences in reported intakes. From the plot and the negative correlation coefficient there is a tendency for subjects to report lower intakes on the second administration of the QFFQ than on the first. This is confirmed by the significantly lower mean maize meal intake reported on the second than on the first administration of the QFFQ (Table 6.17).

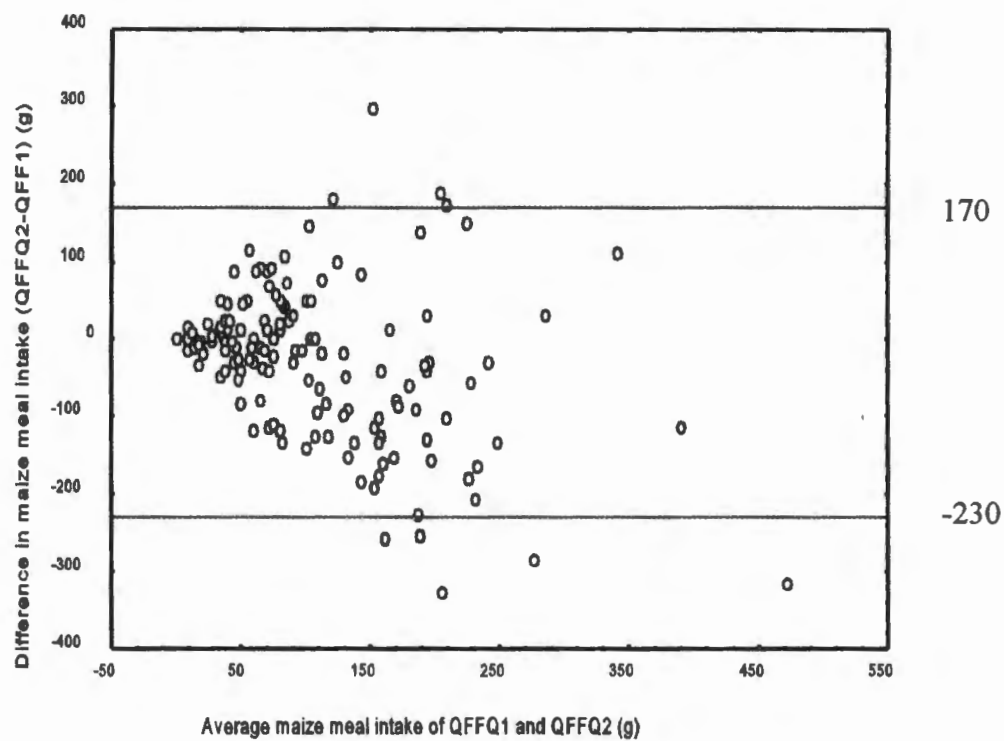


Figure 6.4: Bland-Altman plot for maize meal

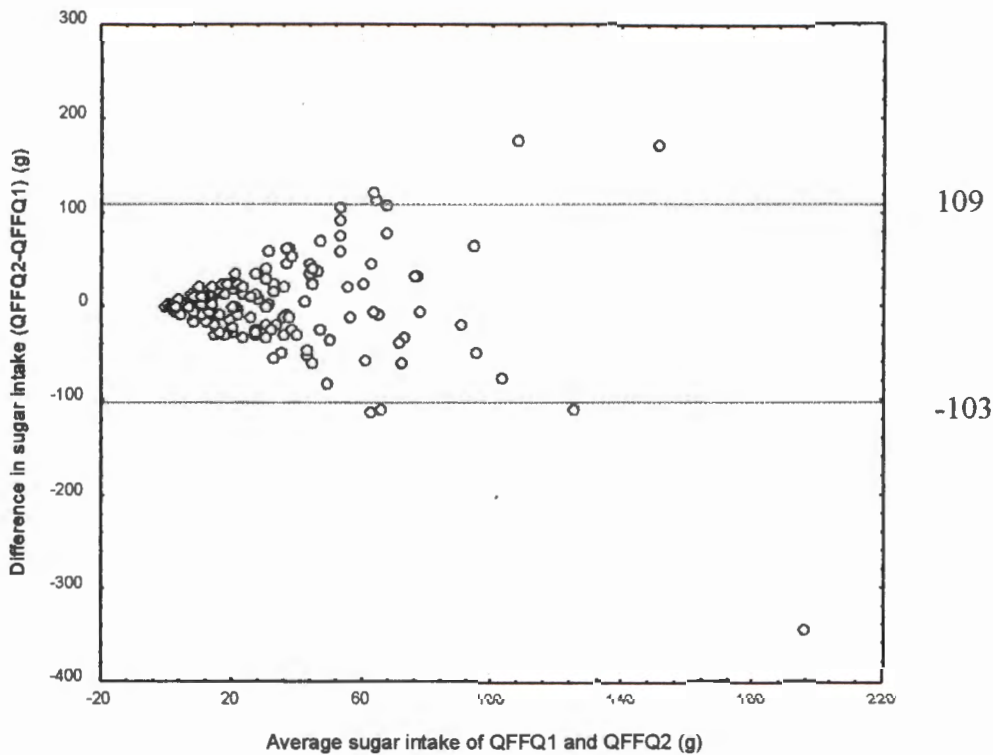


Figure 6.5: Bland-Altman plot for sugar

By contrast, the Bland-Altman plot for sugar (Figure 6.5) shows no bias in the relationship between reported intake and differences between administrations. It is interesting to compare the plots for maize meal and sugar as the main contributors to carbohydrate intake with the plot for carbohydrate (Figure 6.6). Similarly to the maize meal plot, there appears to be a tendency for the results of the first questionnaire to be higher than those of the second. However, this correlation is weak and not significant ($P>0,05$), apparently offset by the lack of bias in the reported sugar intake. Also, comparison of Table 6.8 (mean differences for nutrients) and Table 6.17 (mean differences for food groups) shows that mean reported total carbohydrate intake was similar on both administrations of the QFFQ. Whereas the mean intakes of some carbohydrate rich food groups were higher on the first administration of the QFFQ (maize meal and other cereals) and higher on the second administration for others (fruit, vegetables, samp, bread, sugar and legumes).

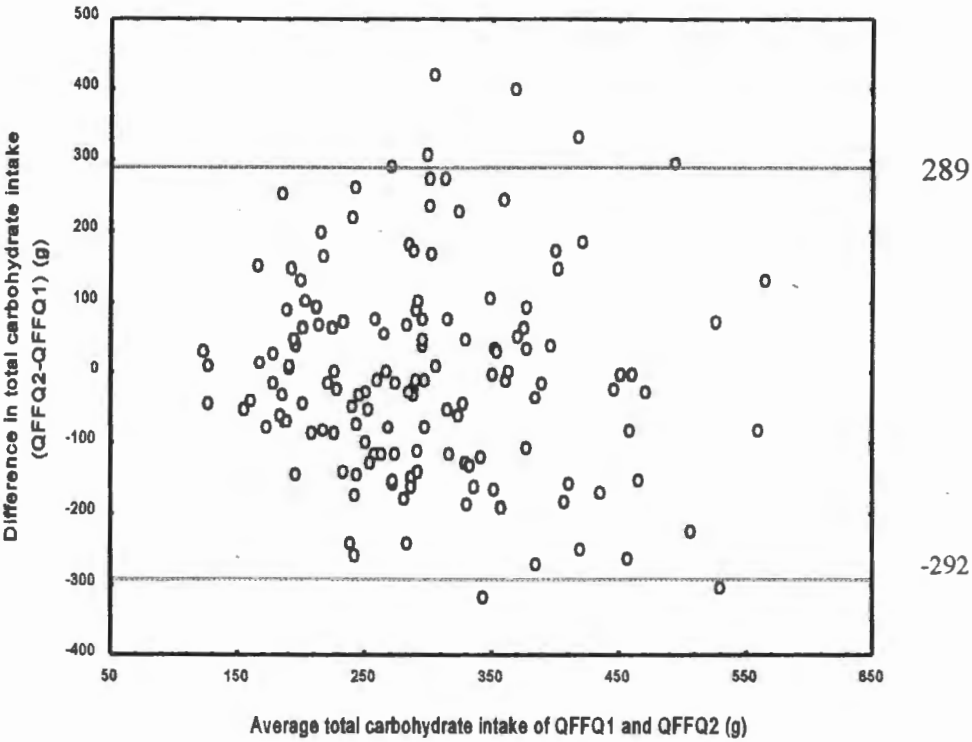


Figure 6.6: Bland-Altman plot for carbohydrate.

The limits of agreement, number of observations outside the limits of agreement and the Spearman rank correlation coefficients for the food groups are summarised in Table 6.20.

Table 6.20: Summary of agreement between food groups (N=144)

Food group	Limits of agreement		Observations outside limits of agreement N	% Agree-ment	Spearman R	95% CI	sds/sm
	Lower	Upper					
Milk (g)	-344	396	3	97,9	-0,123	-0,281-0,041	1,7
Meat (g)	-118	155	8	94,4	0,052	-0,113-0,214	1,1
Fish (g)	- 37	47	7	95,0	0,278	0,120-0,422**	0,6
Legumes (g)	- 99	140	8	94,4	0,318	0,163-0,458***	2,1
Eggs (g)	- 83	91	9	93,7	0,064	-0,101-0,225	1,7
Fruit (g)	-371	252	5	96,6	-0,068	-0,229-0,097	1,4

Food group	Limits of agreement		Observations outside limits of agreement N	% Agreement	Spearman R	95% CI	¶sd/sm
	Lower	Upper					
Vegetables (g)	-133	168	10	93,1	0,160	-0,004-0,315	0,8
Maize meal (g)	-230	170	8	94,4	-0,350	0,198-0,486**	1,3
Rice (g)	-120	120	3	97,9	-0,039	-0,201-0,125	1,6
Samp (g)	-105	102	8	94,4	-0,021	-0,184-0,143	1,4
Bread (g)	-188	215	6	95,8	0,008	-0,156-0,171	1,6
Cereals (g)	-237	219	9	93,7	-0,053	-0,215-0,112	2,0
Fat (g)	- 45	39	4	97,2	0,038	-0,126-0,200	1,8
Sugar (g)	-103	108	8	94,4	0,021	-0,143-0,184	1,8

¶sd/sm=standard deviation of differences ÷ standard deviations of mean. Smaller values indicate better relative agreement; Level of significance: *P<0,05; ** P<0,01; *** P<0,001; 95% CI: 95% Confidence interval

The best agreement was obtained for the milk, rice and fat food groups, while the poorest agreement was obtained for the meat, vegetable and other cereal group. Significant proportional bias was apparent for the fish, legume and maize meal groups.

The results of the Bland-Altman plots for nutrients (Table 6.12) and those of the food groups (Table 6.20) show both similarities and contrasts. Neither calcium nor the milk group show proportional bias. However, the agreement for the milk group is considerably better than that for calcium. Calcium intakes from other food sources thus may account for the poor agreement for reported calcium intakes. Reported total protein intake showed both poor agreement and proportional bias between administrations of the QFFQ. This is reflected in the poor agreement seen in the protein-rich food groups (meat, fish, legumes and eggs). The reported fruit and vegetable intakes could be expected to be reflected in the results of the vitamin A and vitamin C Bland-Altman plots. This appears to be true for fruit and vitamin C (both have 95% agreement), but not for vitamin A. Possibly, the contribution of Vitamin A from the meat and egg groups has decreased the level of agreement. There is an interesting contrast between the Bland-Altman plot for fat as a nutrient and fat as a food group (that is, visible fat). The reported fat intake as a food is consistent between administrations of the QFFQ (97% agreement and no significant proportional bias), while as a nutrient there is weaker agreement (95%) and significant

proportional bias. A possible explanation is that subjects find it easy to report visible fat intake (mainly margarine) but that the reported invisible fat intake is less reliable, similar to the meat and egg group intakes.

6.3.3.4 Agreement between classification into quintiles according to food groups

As for the nutrients, the distributions of the various food groups for the two administrations of the QFFQ were compared for the entire sample and for males and females (Table 6.20).

Table 6.21: Classification of subjects into the same and adjacent quintiles of the distribution for the two administrations of the QFFQ (N=144)

	Entire sample (N=144)				Males (N=45)				Females (N=99)			
Food group	Cumulative %				Cumulative %				Cumulative %			
	*S	±1	±2	±3	*S	±1	±2	±3	*S	±1	±2	±3
Milk	44	83	93	100	33	82	89	98	48	83	94	98
Meat	52	87	98	100	49	89	98	100	53	86	98	100
Fish	78	94	99	100	76	95	100	100	78	93	99	100
Legumes	58	84	96	100	64	89	98	100	55	82	95	99
Eggs	56	88	91	93	40	84	93	98	63	90	94	95
Fruit	51	83	93	100	53	80	93	100	50	85	93	100
Vegetable	43	84	95	100	40	82	91	100	44	85	97	100
Maize meal	50	90	97	100	42	91	96	100	53	89	98	100
Rice	80	95	97	97	78	93	93	98	81	96	99	100
Samp	74	92	98	100	76	93	95	100	73	90	97	98
Other cereals	82	92	92	96	87	91	91	96	79	92	92	96
Bread	58	89	95	99	47	82	91	98	63	92	97	99
Fat	78	94	97	98	98	91	93	99	78	95	98	98
Sugar	73	93	98	98	69	91	100	100	74	94	97	97

S=classified into the same quintile; ±1=adjacent quintiles; ±2= two quintiles difference; ±3= 3 quintiles difference

All food groups show that more than 80% of subjects are classified into the same or adjacent quintiles whereas only seven of the 11 nutrients showed over 80% agreement. There were no significant differences between the proportions of males and females classified into similar

quintiles for any of the food groups ($P>0,05$). The highest levels of agreement (over 90%) were obtained for fish, rice, samp, other cereals, fat and sugar. Importantly, the agreement for maize meal as the staple food was also high (89,5%) with almost 50% classified into the same quintile. It is noticeable that three of the four food groups with high agreement (fish, rice, samp) are foods consumed in relatively small amounts. For example, rice is typically consumed once a week, on Sunday, and would be easy to recall. Sugar also is consumed in fairly constant amounts. For example, subjects are likely to take the same amount of sugar in tea or coffee and to drink very similar numbers of cups per day which would be easy to recall.

6.3.4 Other factors which could influence reproducibility

Some dietary intake studies have found differences in food intake associated with monthly wage payments, with both the quantity and quality of food consumption being higher immediately after payment and then gradually decreasing until the next wage payment (Bryceson, 1989). As most bread winners are paid at the end of the month, this is the time when food in the household is most plentiful. Thus, interviews conducted within the first few days of the month might record higher intakes than in the middle or towards the end of the month when both food supplies and money begin to run out. To test whether this phenomenon occurred in the present study, the first and second administrations of the QFFQ were classified into groups: those done before the fifteenth of the month and those in the second half of the month. Of the 144 subjects interviewed, 40% (57) were interviewed at the same time of the month on both occasions (both interviews were either conducted in the first or both in the second half of the month); 28% (41) were interviewed early in the month on the first administration and late on the second administration and 33% (47) were interviewed after the fifteenth on the first occasion and before the fifteenth on the second occasion. Using the reported energy intake as an indicator, no association could be found between the time of month and the difference in reported intakes between the two administrations of the QFFQ ($P>0,05$). Therefore it does not appear as if the time of month of the administration of the QFFQ affects the reproducibility of the results.

6.4 DISCUSSION

As pointed out in the Literature Review (2.5) comparison of the results of reproducibility studies is difficult because of the many methodological and analytical differences. This is particularly so for the present study as no study on a comparable population (Africans stratified according to strata of urbanisation) could be found in the literature. Nevertheless, viewing the present results in the light of the results obtained by others will aid in the interpretation and evaluation of the study, even if populations and methodologies are not comparable.

6.4.1 Reproducibility for nutrients

The present study tested the reproducibility of the QFFQ over a relatively short time (three to 12 weeks). Thus, the results can be compared with those of other short term reproducibility studies (Chapter 2, Table 2.7). The correlation coefficients obtained in the present study are lower than those reported by other studies with a similar interval (Lindroos *et al.*, 1993; Feunekes *et al.*, 1995; Männistö *et al.*, 1996) and most of those reported for intervals of 12 months or longer (Rimm *et al.*, 1992; Ajani *et al.*, 1994; Schmidt *et al.*, 1994; Wheeler *et al.*, 1994; Stevens *et al.*, 1996; Riboli *et al.*, 1997). The range of correlation coefficients (0,14 to 0,75) was lower than those obtained in studies which also made use of food photographs for estimating portion sizes (Pietinen *et al.*, 1988; Elmståhl *et al.*, 1996a). The values obtained are also lower than the 'satisfactory' range of 0,5 to 0,8 (Kune *et al.*, 1987). The range of correlation coefficients was closest to those obtained for multi ethnic youths (0,26 to 0,58) (Rockett *et al.*, 1995), Latino mothers (0,49 to 0,60) (Basch *et al.*, 1994) and black males and females (0,26 to 0,58) (Stevens *et al.*, 1996). Nevertheless, in the present study, all correlation coefficients, except for that of calcium, were statistically significant ($P < 0,05$).

Although lower, the correlation coefficients in the present study show some similar trends to those reported by other researchers. The most noticeable similarity is that the highest coefficient was obtained for alcohol (0,75) as has been reported in several other studies (Pietinen *et al.*, 1988; Munger *et al.*, 1992; Lindroos *et al.*, 1993; Ajani *et al.*, 1994; Wheeler *et al.*, 1994; Goldbohm *et al.*, 1995). Munger *et al.* (1992) have suggested that nutrient intakes derived from only a

few foods, such as alcohol, may be less variable and easier for subjects to recall use or abstentions. This could also apply to cholesterol that has the second highest correlation and depends on a relatively small number of foods.

The interpretation of the results must consider the limitations of the correlation coefficient. A weak correlation coefficient may reflect a smaller range of intakes rather than weaker agreement when compared to other studies (Delcourt *et al.*, 1994). However, the Spearman rank correlation coefficient is not affected by extreme values. Also, the range of intakes varied widely among subjects. Log transformation, by improving the normality of the distribution, also improves the correlation coefficient (Hebert & Miller, 1991). Likewise, adjustment of nutrients according to energy intake has been found to improve Pearson correlation coefficients (Willett *et al.*, 1985). Several studies, however, have shown only slight differences between unadjusted and adjusted values (Rimm *et al.*, 1992; Goldbohm *et al.*, 1995) while Stevens and co-workers (1996) found that the correlation coefficients not adjusted for energy intakes tend to be higher than those adjusted for energy.

As for the differences between mean reported intakes of the first and second administrations of the QFFQ (Table 6.8), the agreement appears stronger, with only four of the 11 nutrients showing significant differences. Other differences were small, as has been found by other studies (Munger *et al.*, 1992; Forsythe & Gage, 1994; Schmidt *et al.*, 1994; Wheeler *et al.*, 1994; Feunekes *et al.*, 1995). With the exceptions of carbohydrate and alcohol, the mean reported intakes obtained from the second administration of the QFFQ were higher than those obtained from the first. This finding is similar to the trends reported by Schmidt *et al.* (1994) and Männistö *et al.* (1996) but differs from several other studies which reported higher mean intakes on the first than on the second measurement (Willett *et al.*, 1985; Lindroos *et al.*, 1993; Ajani *et al.*, 1994; Wheeler *et al.*, 1994; Feunekes *et al.*, 1995; Rockett *et al.*, 1995; Elmståhl *et al.*, 1996a; Stevens *et al.*, 1996).

The percentage difference for energy between measurements in the present study (5,6%) was slightly higher than that reported by Feunekes and colleagues (1995) over a two-month interval (-1%), Wheeler and colleagues (1994) for a three-month interval (-1,7%) and Schmidt *et al.*

(1994) (2,2%) for a 12-month interval. However, the differences obtained by Wheeler and colleagues (1995) for a short interval (11,2 to 13,6%) were more than double that of the present study. The percentage difference for total protein was also higher than those obtained by Schmidt and colleagues (1994) (2,6%) and Wheeler and colleagues (1995) for the three-month interval (-1,4%) but similar to the range obtained for the shorter interval (-9,6% to -14,6%). The comparative pattern for fat, cholesterol and fibre was similar, with the differences in the present study being higher than those reported by other authors (Wheeler *et al.*, 1994; Schmidt *et al.*, 1994; Feunekes *et al.*, 1995). The only results available for the comparison of the micronutrients are those of Wheeler *et al.* (1994). Again, the percentage differences obtained are closer to those recorded for the four to six week interval than for the three-month interval. In contrast to the present study, the mean intakes reported by Wheeler *et al.* (1994) were lower on the second than on the first measurement.

The Spearman rank correlation coefficients and percentage differences seem to give a conflicting picture of agreement between the two measurements. The Spearman rank correlation coefficients are weak (although significant) which could be interpreted as agreement between the two measurements. On the other hand, the mean reported intakes did not differ significantly, indicating that mean intakes were fairly stable from the first to the second administration of the QFFQ. It must be remembered, however, that these two analyses measure different things. The correlation coefficient measures the linear relationship between the rankings of the two variables while the comparison of means compares the group performance of the measurements. If, as pointed out by Willett (1990), the reproducibility coefficient provides only an estimate of a lower limit of consistency, the reproducibility of the QFFQ could be considered to be satisfactory.

In an attempt to further clarify the extent of agreement between the two administrations of the QFFQ, two other analytic procedures were applied. The Bland-Altman procedure (Bland & Altman, 1986) provides an objective measurement for defining relative agreement and identifying bias. As with the previously mentioned analyses, agreement seemed to differ among nutrients. The best agreement (95% or more of subjects within the limits of agreement) was obtained for total protein, total carbohydrate, total fat, cholesterol, fibre and vitamin C. Alcohol, in contrast to the correlation coefficient, showed the lowest percentage agreement (Table 6.12). A factor

which is shown by the Bland-Altman method and not by the other measures is that of proportional bias (as the mean intake increases so the second measurement becomes higher than the first) in the reproducibility of total protein, total fat, fibre and vitamin C. These nutrients also showed the largest percentage differences between first and second measurements. This suggests that the extent of reproducibility may be influenced by the level of intake, that is, reporting of low intakes may be more reliable than that of high intakes. Possible further analyses to investigate this would have been to divide the distribution into categories according to the mean of the first and second measurements, and then to compare correlation coefficients and percentage differences. In their extension of the Bland-Altman method, Delcourt and co-workers (1994) show that the smaller the ratio of intra-individual variation (standard deviation of differences, sd) to inter individual variation (standard deviation of means, sm), the better the relative agreement. Accordingly, energy shows almost perfect agreement (1,1). This is supported by both the small percentage difference (5,6%) and the higher correlation coefficient between measurements. Despite the relatively low percentage agreement on the Bland-Altman method (85%), alcohol showed good agreement according to the intra-, inter-individual variation ratio (1,3). The poorest relative agreement was obtained for calcium (1,9). Thus, the low reproducibility correlation for calcium (0,14) may be due to high intra-individual variation, rather than inter-individual variation (the mean percentage difference was only 3,2%).

The final test of reproducibility was to assess whether the QFFQ was able to place a subject into the same subgroup of intake on both administrations. Given five quintiles of distribution, the expected percentages of subjects placed in the same, in the same or within one quintile, or greater than one quintile by chance alone are 20%, 52% and 48% respectively (Kune *et al.*, 1987). The measurement of energy showed the least ability to classify subjects into the same quintile, with only slightly more subjects than would be expected by chance being placed in the same category (Table 6.13). For the other nutrients, agreement in the same quintile was higher (mean=45,8%, SD=19,1%). The percentage of subjects classified within one quintile was considerably higher than would be expected by chance, indicating relatively good agreement. In comparison to the results obtained by Kune *et al.* (1987), the present study showed a lower level of agreement within the same quintile, but a similar agreement within the same and adjacent quintiles. Thus, the QFFQ seems better able to classify subjects within one quintile, than into the same quintile of the distribution. The highest level of agreement was for vitamin C (97% within one quintile).

This finding may help to explain why vitamin C showed a relatively good correlation coefficient (0,38) but the highest percentage difference between measurements (22%). The second interviews were conducted at the beginning of the citrus season (May-June) and the North West province is a citrus producing region. Therefore, oranges were plentiful. Thus, the entire distribution of vitamin C intake was shifted upwards, resulting in large differences in intakes, but few differences in the ranking of individuals within the distribution. The poorest quintile agreement was obtained for calcium which corresponds to the poor correlation coefficient and sd: sm ratio showing poor intra individual agreement despite little difference in mean intakes.

6.4.1.1 Reproducibility according to gender

Comparison of reproducibility measures between subgroups showed few differences. The correlation coefficients for females were slightly higher (but not significantly) than for males (Table 6.4) while the mean percentage difference for females (8,0, SD=6,7) was lower than that of the males (13,0%, SD=13,7) ($P<0,05$). There was no difference in the quintile distribution between genders. Since women are more involved with food procurement and preparation, they might be expected to recall food intakes more accurately than men. Some studies comparing reproducibility of males and females have shown no differences (Ajani *et al.*, 1994) or slightly better reproducibility among the males than among the females (Stevens *et al.*, 1996). The differences in correlation results could be due either to greater changes in the diets of one gender compared to the other or to better accuracy on the part of one gender (Stevens *et al.*, 1996).

6.4.1.2 Reproducibility according to strata of urbanisation

The farm worker stratum appeared to give the least reproducible results of the strata of urbanisation with all assessment measures. Several nutrients showed negative correlations (total fat, cholesterol, calcium and vitamin A) and the only significant correlation coefficient was for alcohol (Table 6.5). Also, the correlation coefficients for cholesterol and calcium were significantly different to those of the rural and middle class strata. According to the percentage mean differences, the only significant differences between strata were for vitamins A and C. The

poor performance of the farm worker stratum may have been due in part to methodological difficulties. The only time which was available for the repeat interviews was a Saturday morning, the farm worker 'free' day. Farm workers are paid on Friday, and many use their money to buy alcohol. Although the interviews were conducted in the morning, many of the subjects had obviously consumed a fair amount of alcohol and gave the impression that their responses could not be trusted. This observation is supported by the fact that the farm workers had the most monotonous diet of all the strata (see Chapter 8; 8.6) and therefore should have had good reproducibility. Interestingly, the best correlation for alcohol was obtained for the farm worker stratum.

It is encouraging to note that no significant differences in reproducibility occurred among strata for energy or the macronutrients (except cholesterol) and the only significant differences were for micronutrients. Thus, it appears that the level of urbanisation did not affect reproducibility to a meaningful extent.

6.4.1.3 Reproducibility according to age groups

Age did not appear to affect reproducibility. Overall, the youngest age group showed the weakest correlations but the smallest percentage differences for most nutrients. Neither correlation coefficients nor percentage differences, however, differed among age groups. The poor correlation coefficients of the youngest age group are similar to the comparison of studies in which the youngest subjects (Rockett *et al.*, 1995) gave the weakest correlations. The weak correlation coefficients in the present study, however, may be a reflection of the small sample size (15) rather than of poorer reproducibility. Regarding percentage differences, some interesting points can be seen. For example, the percentage difference for vitamin C for the 15 to 24,9-year and the 35 to 45,9-year age groups were higher than 60% (Table 6.10), but was only -5% for the 25 to 34,9-year age group and -0,2 for the age group older than 45 years. These results, however, may simply be spurious, and not related to age. Stevens and co-workers (1996) in their study of subjects between the ages of 45 and 64 years, reported better correlations among subjects younger than 50 years than those older than 50 years. In the present study, there was no pattern with regard to age in the groups older than 25 years (Table 6.6). These results are similar to

those of Colditz *et al.* (1987) who found no significant differences in reliability coefficients among tertiles of age in their reproducibility study of 1497 female nurses between 33 and 58 years of age.

6.4.1.4 Reproducibility according to body mass index

Since there are a number of reports in the literature of obese subjects underreporting their dietary intakes (Bandini *et al.*, 1990; Hultén *et al.*, 1990), it was thought that reproducibility might differ among subgroups classified according to BMI (Table 6.7). BMI, however, did not appear to influence reproducibility. The group with a low BMI appeared to perform slightly better using correlation coefficients than the other groups. The only significant differences between correlation coefficients occurred between the low BMI group and the normal range group for iron and the obese group for vitamin C. Lindroos *et al.* (1993) obtained Pearson correlation coefficients with a range of 0,61 to 0,89 in a group of 111 obese subjects which is comparable to the ranges obtained by non-obese subjects in other studies (Willett *et al.*, 1985; Rimm *et al.*, 1992; Ajani *et al.*, 1994; Männistö *et al.*, 1996). When reproducibility was assessed using percentage differences, the obese group obtained smaller differences than the other groups, with the mean percentage difference (6,8, SD=9,4) being significantly lower than the low and normal BMI groups (15,1 SD=16,8 and 14,4 SD=17,9 respectively). The results of the present study are in agreement with those of Lindroos *et al.* (1993) who concluded that the reproducibility of QFFQ administered to obese subjects did not differ from that of normal BMI subjects

A possible shortcoming of the present study was that subjects were not weighed at the second measurement. Thus, changes in intakes could not be correlated with weight changes.

6.4.2 Reproducibility for food groups

The reproducibility of the QFFQ in terms of food groups followed the same pattern as that of nutrients with no significant differences between the mean correlation coefficient or the mean percentage difference between nutrients and food groups ($P>0,05$). Similarly as for the nutrients, there were considerable differences in the reproducibility of food groups. According to the Spearman rank correlation coefficients, the meat group showed the highest level of reproducibility

($R=0,54$, Table 6.14). This correlation coefficient is comparable to the coefficients obtained for beef by Kune *et al.* (1987), for meat products by Ajani *et al.* (1994) (0,29 to 0,64), for beef and pork (0,56) and poultry (0,52) by Männistö *et al.* (1996) and for the long term interval for meat (0,60) by Riboli *et al.* (1997). The correlation coefficient obtained for vegetables (0,45) was lower than the coefficients of 0,66 reported by Männistö *et al.* (1996) and of 0,61 to 0,73 reported by Elmståhl *et al.* (1996a). It fell within the same range as coefficients for vegetables reported by Kune *et al.* (1987) (0,35 to 0,47), Ajani *et al.* (1994) (0,4 to 0,61), and Riboli *et al.* (1997) (0,37 to 0,65). Maize meal showed a reproducibility correlation coefficient (0,45) which was higher than coefficients obtained for rice, samp, bread and other cereals (0,26 to 0,33). Riboli and co-workers (1997) reported a similar range of reproducibility coefficients for cereals for their long term study (0,32 to 0,42) and slightly higher values over the short term (0,54 to 0,58). The range of coefficients obtained for cereals in the present study is lower than those reported for cereal products by other studies (0,62 to 0,69). The correlation coefficients of the other food groups were generally lower than those reported in the literature.

As would be expected, the reported mean intakes on the second administration of the QFFQ were higher than on the first administration. The important exceptions were the milk group and maize meal which were lower on the second administration (Table 6.17). (Calcium, however, was higher on the second administration. Other sources of calcium such as canned fish, meat and legumes may have made a larger contribution to the total calcium intake on the second measurement). Although maize meal showed a relatively high Spearman rank correlation coefficient, it also showed the third highest percentage difference. This could indicate large inter individual differences. The other foods with high percentage differences were fish and legumes, both of which showed poor reproducibility with the Spearman rank correlation coefficients. The increases in fruit and vegetable intakes correspond to the increases in vitamin C intake. The smallest percentage differences were obtained for rice, samp and sugar.

The Bland-Altman plots may help to explain some of the apparently contradictory results obtained using correlations and differences between means. The plot for maize meal (Figure 6.4) shows a significant, negative correlation, suggesting that, at high intake levels, the first administration of the QFFQ produced higher values than the second. At the same time, 95% of the subjects

fell within the limits of agreement and the sd:sm ratio was relatively small. Taken together, these results could indicate satisfactory reproducibility of maize meal at low and moderate intakes, but a lessening of agreement at high intake levels. Milk shows a high percentage of subjects within the limits of agreement, in spite of the poor results obtained on the previous analyses. However, the limits of agreement are very wide (740 g) as is the sd:sm ratio, confirming a high level of intra individual variation. Based on the sd:sm ratio, the food groups showing the smallest degree of intra individual variation are meat (1,1), fish (0,6) and vegetables (0,8). The highest intra individual variation was displayed by legumes (2,1), miscellaneous cereals (2,0), fat (1,8) and sugar (1,8).

From the quintile distribution, it seems that the QFFQ was better able to classify subjects into the same category of food group intake on both administrations than it was to classify subjects into the same intake category of nutrients. The percentages of subjects classified into the same quintile of the distribution on both administrations (Table 6.21) were approximately double the percentages obtained for nutrients (Table 6.13). The cumulative percentage of subjects within one quintile, however, was similar for both nutrients and food groups. The food group quintile distribution results compare well with results obtained by other studies. Kune *et al.* (1987) obtained a higher level of agreement than the present study for the meat group (94% and 87% respectively) but a lower level of agreement for the vegetable group (80% and 84%) respectively. A similarity between the study of Kune *et al.* (1987) and the present study was that in both studies, vegetables showed among the lowest quintile agreements.

The results of the reproducibility of food groups between subgroups (gender, strata of urbanisation and age group) did not differ significantly. Generally, the level of reproducibility was better in the urban middle and upper class strata and poorest in the farm stratum. The pattern of reproducibility according to age groups was similar to that of the nutrients, with the youngest age group showing the best reproducibility on the comparison of mean intakes, but poor reproducibility based on the Spearman rank correlation coefficient.

6.4.3 Factors which may have affected reproducibility

In comparison to other reproducibility studies, the QFFQ appeared to perform poorly, especially when analysed by Spearman rank correlations. When the other analyses were included, however, the reproducibility appears more satisfactory. A number of factors, including the QFFQ itself, changes in the subjects' eating patterns and methodology may have affected the level of reproducibility of the QFFQ between the first and second administrations.

Ideally, the test and the retest should be administered under the same circumstances (Judd, 1991). In the present study, however, the circumstances of the two interviews differed considerably. The first administration of the QFFQ was done at the same time as the measurements of the THUSA project (Chapter 5). The research centre was very busy and subjects were exposed to a range of tests and measurements which lasted more than two hours. In contrast, on the repeat visit only the QFFQ was administered. Generally the research centres were quiet and there were fewer distractions. In addition, the whole research set up, including the dietary intake assessment, was something completely new and strange to all the subjects (except possibly some of the subjects at the University of North West). Therefore, it is reasonable that some of the subjects may have felt intimidated or nervous when the QFFQ was administered the first time. At the repeat interview, the subjects knew what to expect, had received some feedback from the first session and were familiar with researcher and field workers. Thus, subjects might have felt more relaxed and free to answer the questions honestly and able to recall items more easily.

A factor which may have affected the reproducibility was that different field workers administered the questionnaire on the two measurements. The interviewers were not kept the same for practical reasons. Since the subjects were volunteers and might not have come the second time, it could have happened that at the repeat interview one field worker had several subjects, and another only one or two. Also, on the occasion of the repeat interview, some of the field workers helped to trace subjects, and so were not available to conduct interviews. In order to distribute the work load efficiently and to avoid keeping subjects waiting for too long, subjects were allocated randomly to field workers on both the first and second administrations of the QFFQ. It is difficult to know whether better reproducibility would have been obtained had the same field

worker conducted the interviews on both occasions. Smith and colleagues (1996) found little difference in reproducibility coefficients when interviews were conducted by the same or different interviewers. Administration by a different field worker on the second administration may have advantages. Teufel (1997) has suggested that administration by a different interviewer may reduce the respondent's need to recall earlier responses by removing the feeling of being checked by the same field worker. Also, using different field workers gives an indication of the effectiveness of the QFFQ when administered by an unfamiliar interviewer (Teufel, 1997).

With regard to eating patterns, it is unlikely that these would have changed meaningfully during the relatively short interval between administrations. As already pointed out, seasonal changes could have resulted in the higher intakes of oranges and thus of vitamin C. Although the subjects were asked whether any of their circumstances had changed during the intervening period, none answered in the affirmative. Ajani and co-workers (1994) obtained a similar response in their study when they asked subjects the same question. These authors suggest that there may have been changes in eating patterns, but these may have been subtle and gradual. Subjects may not have noticed the change or may not have wanted to report it. Another possibility is that subjects might not have thought that changes in their circumstances could have been relevant to their food intake. An example of where this might have occurred was a subject in the rural stratum. The subject (a young man) responded negatively to the question on changed circumstances. When the section on snacks and sweets was reached, he reported unusually high intakes and then commented that he was running a tuck shop. On further questioning, it turned out that he had opened his shop in the time since the first assessment. Thus, his snack intake was considerably higher on the second administration.

In agreement with other studies (Kune *et al.*, 1987; Pietinen *et al.*, 1988a; 1988b; Ajani *et al.*, 1994; Basch *et al.*, 1994; Schmidt *et al.*, 1994; Wheeler *et al.*, 1994; Rockett *et al.*, 1995; Stevens *et al.*, 1996) the level of reproducibility varied between nutrients and food groups. Several authors have suggested that frequently consumed foods have better reproducibility than other foods (Ajani *et al.*, 1994; Feunekes *et al.*, 1995; Männistö *et al.*, 1996). Pietinen *et al.* (1988b) found that reproducibility was generally best for foods eaten infrequently and for foods eaten daily. When all the analyses were taken together, maize meal, the staple food of the

population, appears to have satisfactory reproducibility. The reproducibility of rice, which is consumed in small amounts relative to maize meal was also good. This could be because rice was regularly eaten on Sundays and thus its consumption would have been easy to recall. Sugar also showed fairly good reproducibility (except for the Spearman rank correlation). Sugar was consumed mostly in tea and coffee and the same amounts were generally used per cup. Also, the number of cups consumed daily was fairly constant for an individual. Therefore, reproducibility could be expected to be good. Foods consumed irregularly such as the miscellaneous cereal group, samp and legumes showed relatively low reproducibility. The fact that reproducibility is related to the frequency of consumption of foods must be kept in mind when comparing results from different populations. As the frequency of consumption of food types differs among populations, a food with good reproducibility in one study may give poor results in another population where it is consumed irregularly.

6.5 CONCLUSION

In order to collect accurate and reproducible food intake data, it is essential that the instrument performs consistently from one administration to the next and is able to identify true changes in dietary intakes. An assessment of reproducibility of the present QFFQ based only on Spearman rank correlation coefficients gave the impression that the reproducibility, especially in comparison to other published results, was low. Satisfactory reproducibility, however, is also reflected by small differences between the means of each measurement, no proportional bias, and a high percentage of subjects classified within the same or adjacent quintiles on both occasions. Thus, alcohol and vitamin A show the best reproducibility by performing well on all measures. Energy and carbohydrate showed satisfactory reproducibility, although the percentages of subjects classified within one quintile were lower. For all the other nutrients, reproducibility was satisfactory on at least two of the analyses. It is reassuring that reproducibility was consistent across all subgroups. It can therefore be concluded that the QFFQ was a relatively reproducible dietary intake assessment instrument.

CHAPTER 7

RELATIVE VALIDATION

7.1 INTRODUCTION

The relative validity of the quantitative food frequency questionnaire developed for use among the African population of North West province was tested concurrently to the main dietary intake study. The relative validity was tested, first, by comparison to energy and nutrient intakes derived from seven-day weighed food records kept by 74 volunteers and second, an attempt was made to validate nitrogen intakes against nitrogen excretion in 24-hour urine collections from 88 volunteers. An additional measure of relative validity was the ratio of reported energy intake to estimated basal metabolic rate. In the light of the recent developments in statistical techniques for the analysis of validation data, both well known techniques such as Spearman rank correlation coefficients, paired t-tests and frequency distributions, and more recently proposed techniques including Bland-Altman plots and structural equation models, were used and the results compared. This chapter describes the methods used and the results obtained for the various aspects of the relative validation study. The results are discussed with reference to other published studies and an attempt is made to reach a conclusion about the relative validity of the use of the QFFQ in the main dietary intake study.

7.2 METHODS

7.2.1 Seven-day weighed record

7.2.1.1 Sample size and selection

As keeping a weighed food record imposes a considerable burden on a subject, only volunteers were recruited until a sample of 74 usable weighed records was collected. Reading and some simple arithmetic ability is necessary for a subject to be able to keep a weighed record. Thus, only literate subjects were recruited. The field workers identified suitable subjects during the initial interviews, briefly explained what the weighed record involved and referred them to the

researcher. The researcher then explained the weighed record in more detail, confirmed that the subject was literate and recorded the subject's name, address, telephone number, directions and alternate contact details (Appendix I). Volunteers were also asked to sign an informed consent form, specifically for the weighed record.

Subjects were recruited from all strata except the farms. This was because most farm workers were illiterate. Also, for practical reasons, subjects were not recruited from all centres. For example, subjects were not recruited from the Groot Marico district, as this was the first visit of the THUSA study and the researcher and field workers needed time to get used to the basic data collection procedures, before the extra work involved with the weighed record was added, most of the subjects were illiterate and, because of the distance involved, return visits to check and collect weighed record would have been difficult. In order to make up the numbers of the sample, thirty subjects, who met the criteria for the THUSA study were recruited from the Ga-Rankuwa area. All subjects were given a small payment on completion of the seven-day food record.

7.2.1.2 Data collection

A seven-day food diary (Appendix J) was used by the subjects to record their food and drink intake for seven consecutive days. Detailed instructions and examples were given at the beginning of the diary. Each day was divided into time periods to facilitate recording of foods and columns were given for recording the time of consumption, the type, description and preparation method of the food or drink consumed and the weight or volume served and left over. The last two columns were used by the researcher to calculate the amount of food consumed and the food code for analysis. A list of snack foods and drinks was placed on the last page for each day, as a reminder, in case the subject had forgotten to record these during the day. Space was allowed for the subject to write recipes used during the recording period.

In addition to the food diary, each subject was given a diet scale with a capacity of 500 g and 5 g graduations (EKS, France), a measuring jug (500 ml capacity, 25 ml graduations) and a set of four measuring spoons (1 ml, 2 ml, 5 ml, 12,5 ml). As most of the subjects had never used measuring equipment (only some of the upper class urban subjects had measuring equipment of

their own), the use of the scale, measuring cup and spoons was explained and demonstrated. Subjects were asked to weigh something (for example, stiff porridge, apple, potato, slice of bread) and to measure liquid themselves to ensure that they were able to use the equipment correctly. The researcher explained, using examples, how to complete the food diary. Subjects were instructed to weigh or measure all food and drink consumed over a seven day period, starting on the following morning. The subjects were given the researcher's telephone number in case they had queries during the recording period. Whenever possible the weighed records were checked on the second or third day of recording. After the seven-day recording period, the record book and equipment were collected by the researcher, either by asking subjects to meet at the data collection centre or by going to the subjects' home. The researcher went through the record with the subject to clarify what had been recorded and to get additional information, if necessary.

7.2.1.3 Statistical analyses

The amounts of food consumed (weight of food served-weight of food remaining) were calculated and entered into the FoodFinder (Grant *et al.*, 1992) program by the researcher. The average daily intake was calculated by the 'Meals/person' module of the FoodFinder program (Grant *et al.*, 1992). The same analyses for comparison of the food and nutrient intakes from the weighed record and the QFFQ were done as previously described for the reproducibility study (6.2.3), that is, Spearman rank correlation coefficients to test the correlation between the average daily intake from the weighed records and the QFFQ, t-test for paired differences between the mean intakes, the quintile distribution and Bland-Altman plots (Bland & Altman, 1986; 1995). Spearman rank correlation coefficients were compared for genders. Separate quintile categories were established for the QFFQ and the seven-day weighed records from their respective nutrient intake distributions. The same programmes, Statistica (Statsoft, 1995) and Fox Pro (Microsoft, 1993) used for the reproducibility study were used. The level of significance was set at five per cent. In addition to comparisons of nutrient intakes between the two methods, food intakes were also compared using the same tests as mentioned above.

The variance components of the relationship between the weighed record (reference method) and the test method (QFFQ) were estimated by the procedures described by Beaton (1991), modified

by the method of Dunn (1991). In addition, structural equation models (SEM) were used to describe the relationships between nutrient intakes derived from the QFFQ and the true intakes. This procedure is described in detail in Section 7.2.4.

7.2.2 24-Hour urinary nitrogen

7.2.2.1 Sample size and selection

Volunteers were recruited from all strata of urbanisation until a sample size of 104 subjects was achieved. A similar process was used as for the recruitment of subjects for the seven-day weighed record. The researcher explained to the volunteers what the collection of the urine sample entailed. Volunteers still willing to participate were asked to sign an informed consent form specifically for the urine collection. All subjects were given a small payment on the collection of the urine sample. A subsample of 46 subjects completed both the weighed record and the 24-hour urine sample.

7.2.2.2 Urine collection

In order to validate the completeness of the 24-hour urine collections subjects were given three 80 mg tablets of para-aminobenzoic acid (PABA; PABACheck, Laboratories for Applied Biology, London) to take with meals on the day of urine collections (Bingham & Cummings, 1983). PABA is a B-complex vitamin which is harmless to the subject, unaffected by food intake, rapidly absorbed from the digestive tract by simple diffusion and completely excreted within four to eight hours as 4-acetamidobenzoic acid and 4-acetamidohippuric acid (PAH). Specimens containing less than 85% (205 mg) PABA were considered incomplete (Bingham & Cummings, 1983; Black *et al.*, 1995).

Each volunteer was given two, two-litre plastic bottles marked with the subject's study number, in an opaque bag, a safety pin to pin on his or her under wear as a reminder to collect the urine, the three PABA tablets, an instruction sheet and form to record the time of each urine output and any medications taken, problems experienced or specimens missed. Female subjects were given a jug to facilitate urine collection. The instruction sheet was printed in English and Tswana

(Appendix K). Subjects were instructed to collect urine the following day. They were asked to discard the first urine passed that day and from then on to collect all urine passed for a complete 24 hours, including the first specimen passed the following day. Explanations were given to the subjects in Tswana or English and the subjects were asked to repeat the instructions to ensure that they understood them. Subjects were asked to bring the urine collections to the research centre before 09h00 on the morning of the last collection (two days after they were given the instructions). On collection of the urine specimens, the researcher and one of the field workers went through the record sheet with the subject to make sure that the instructions had been followed and to check whether any medication had been taken. The volume of the 24-hour collection was recorded and four portions stored at -20° C before analysis.

PABA content of the urine specimens was analysed by chromatography, as described by Bingham and Cummings (1983). Nitrogen was determined by the Kjeldahl technique. Nitrogen analyses were done by the Potchefstroom Agricultural College.

7.2.2.3 Statistical analyses

The equivalent protein intake to the nitrogen content of the urine sample was adjusted to take skin and faecal losses into account using the formula:

$$\text{protein intake (g/day)} = 6,25 (\text{UUN} + 0,031 \text{ BW})$$

where UUN is urine urea-nitrogen (g/l) and BW is body weight (kg) (Maroni *et al.*, 1985; Porrini *et al.*, 1995).

According to the PABA analyses, 16 specimens contained no PABA. These were excluded from further analyses. Of the remainder (88), 32 specimens (36%) were complete (PABA > 85%) and 56 (64%) were incomplete. However, all these specimens were included in the further analyses (N=88) (O'Donnell *et al.*, 1991).

Statistical analyses included the calculation of the means and standard deviations of the nitrogen and calculated protein and the distribution of the calculated urinary protein into quintiles. Spearman rank correlation coefficients were calculated for the urinary protein and the dietary protein obtained from the QFFQ and, for the subsample who had completed both the weighed

record and 24-hour urine sample, between urinary protein and dietary protein calculated from the weighed record. Bland-Altman plots (Bland & Altman, 1986; 1995) were drawn for protein. The ratio of urinary nitrogen to dietary nitrogen (UN: NI) (from the QFFQ and weighed record for the subsample) was calculated for each subject. Subjects with a UN: NI ratio greater than one were taken as underreporters (Black *et al.*, 1995).

7.2.3 Anthropometry

As described in Chapter 5 (5.6.2) anthropometric measurements were taken for all subjects and the BMR calculated according to the Schofield equations (Schofield, 1985). The ratio of energy intake to BMR (EI: BMR) was used as an indication of the relative validity of the reported energy intakes calculated from the QFFQ of the entire sample as well as from the repeat QFFQ of the reproducibility subsample and the seven-day weighed records. EI:BMR ratios of less than 1.2 were considered an indication of underreporting (Bingham, 1991).

To further describe underreporting the EI: EE was plotted against the UN: NI for the 24-hour urine subsample.

7.2.4 Validation by means of structural equation models (SEM)

The previously mentioned statistical analyses comparing the QFFQ with the seven-day weighed record, assumed that the seven-day weighed record represented the 'true' habitual intake of the subjects. However, in reality the seven-day weighed record may be biased and contain errors, both random or systematic and within or between subjects (Kaaks *et al.*, 1994b). Figure 7.1 shows the possible relationships between the intake obtained from the QFFQ and the true intake.

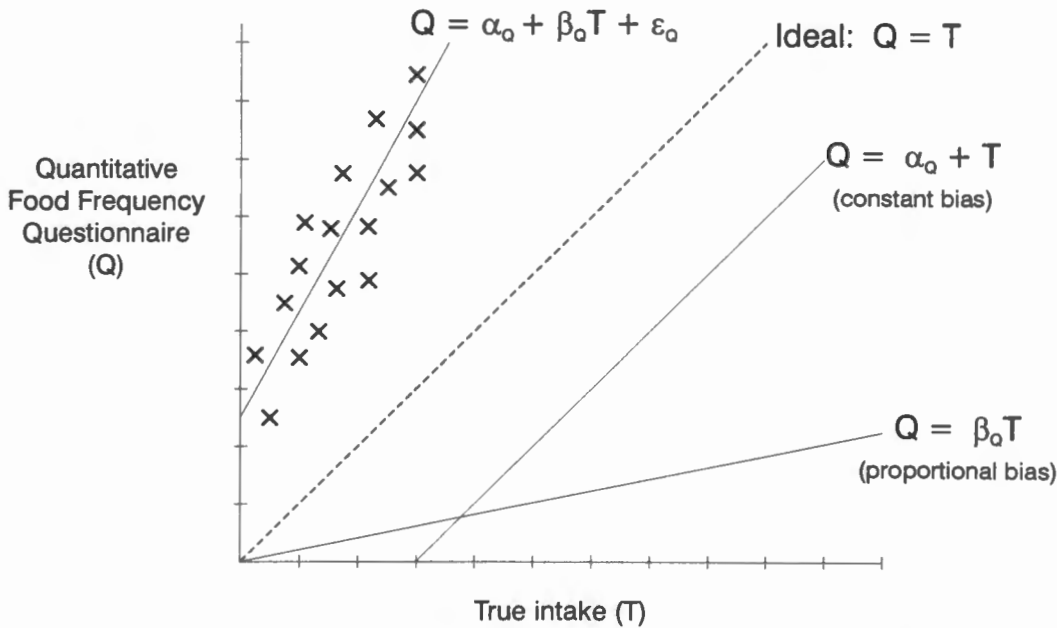


Figure 7.1: Graph showing the ideal, constant bias, proportional bias and real relation between QFFQ intake and true intake

In order to study the effect of the error terms on the correlations between the results of the QFFQ and the results from the weighed records, the procedures described by Kaaks *et al.* (1994b) were applied to the energy and nutrient intakes obtained from the QFFQ and the seven-day weighed record of the validation sample ($N=74$). From the seven-day weighed records and the preliminary study (Chapter 3), food intake on weekend days and especially on Sundays when a wider variety of food and preparation methods were used, appeared to differ considerably from that of week days. In the light of this, it was thought that the variation when weekend days were excluded might be lower than for the complete seven days and give better results. Thus, analyses were performed using both the complete seven-day weighed records and the records for the five week days.

The procedure which includes a third measure was applied firstly to protein intake of a subsample of subjects who had completed the QFFQ, weighed record and 24-hour urine sample ($N=46$) and secondly to energy intake where estimated BMR served as the biological marker ($N=74$). In both cases both five and seven day records were used.

Protein values from the QFFQ were first transformed to improve normality using the Box-Cox power transformation $y = (x^\lambda - 1) / \lambda$, where $\lambda = -0,28$ (Statsoft, 1994). However, λ did not differ significantly from 0 (see Figure 7.2) and was chosen as zero (i.e. log (base e) transformed). The values of energy and nutrients from both the QFFQ and the weighed records were also log (base e) transformed ($\lambda = 0$).

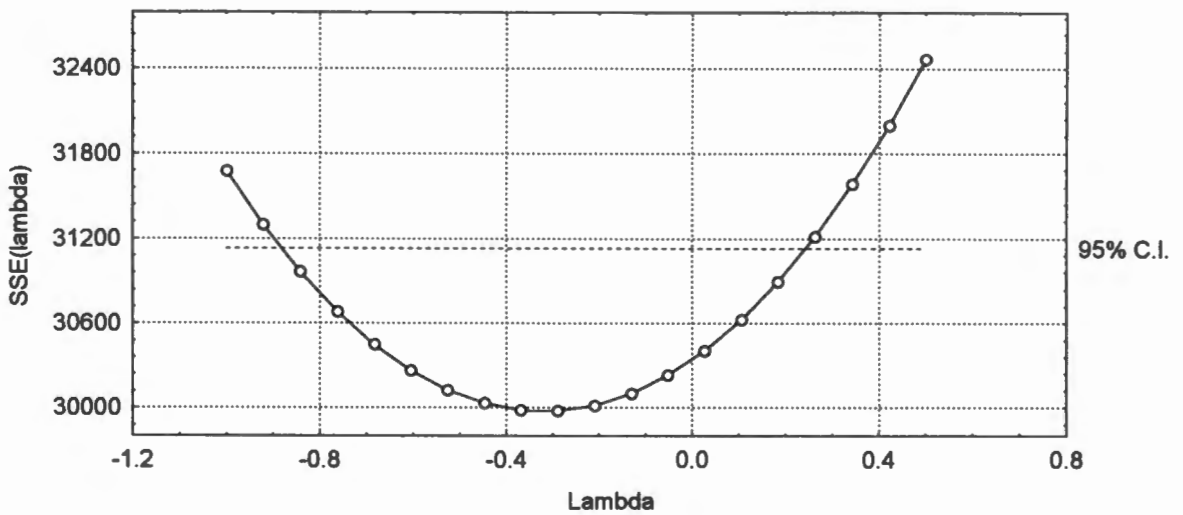


Figure 7.2: Plot of lambda versus sum of squares error (lambda) showing that lambda does not differ significantly from 0 for protein intake obtained from the QFFQ.

7.2.4.1. Estimation of the error parameters

All the following equations and calculations follow the description of Kaaks *et al.* (1994b).

The nutrient intake obtained from the QFFQ (Q) is assumed to be related to the true intake (T) of the subjects by

$$Q = \alpha_Q + \beta_Q T + \varepsilon_Q \quad (1)$$

In order to estimate the accuracy (that is the validity and precision) of the QFFQ the sizes of the unknown error parameters α_Q , (constant bias), β_Q (proportional bias) and $\sigma^2_{\varepsilon_Q}$ (variance of random errors) are needed. Ideally, these estimates would be obtained by comparing the intakes

derived from the QFFQ with the true intake values. In reality, the true intake value can never be known and must be considered as a value of a latent variable (T). Instead the values from the QFFQ must be compared with a 'reference' measurement R (seven-day weighed record) which is related to the same latent variable but may itself contain some error

$$R = \alpha_R + \beta_R T + \varepsilon_R \quad (2)$$

It was assumed that the latent true variable T and observed measurements Q and R had normal distributions and that all random measurement errors, ε , were normally distributed. The expected measurements $E(Q|T)$ and $E(R|T)$ are assumed to be linearly related to the same latent variable T. Thus, under the assumption of joint multivariate normality, the expected measurements should also be linearly related

$$E(Q|T) = \alpha'_Q + \beta'_Q E(R|T) \quad (3)$$

where $\alpha'_Q = \alpha_Q - \beta'_Q \alpha_R / \beta_R$ and $\beta'_Q = \beta_Q / \beta_R$. The reference measurements are assumed to be without either constant or proportional bias (i.e. $\alpha_R = 0$ and $\beta_R = 1,0$) so that $\alpha'_Q = \alpha_Q$ and $\beta'_Q = \beta_Q$.

Equations (1), (2) and (3) define structural relations that would be expected to be observed between the measurements of Q and R. The unknown parameters in the structural relations model were estimated using firstly the energy and nutrient intake values from the QFFQ and seven-day weighed record and secondly from the QFFQ and the weighed records of five week days.

The correlation between the intake derived from the QFFQ (Q) and the true intake (T) is expressed as:

$$\rho(Q,T) = (1 + (\sigma^2_{\varepsilon_Q} / (\beta^2_Q * \sigma^2_T)))^{-1/2}$$

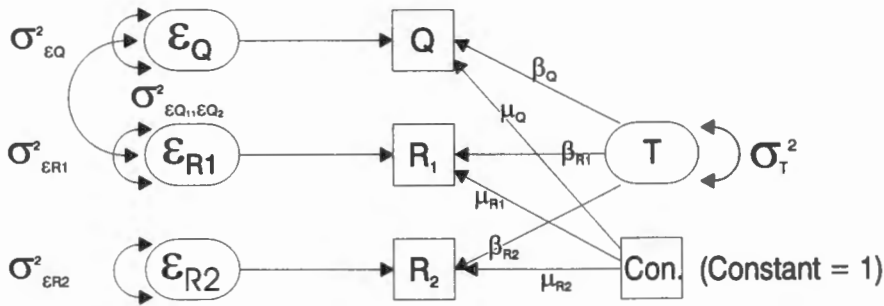
Where $\text{Var}(T) = \sigma^2_T$.

$\rho(Q,T)$ is also known as the validity coefficient (Kaaks & Riboli, 1997).

The CALIS procedure of the SAS version 6 (SAS Institute, 1989) was used to calculate the maximum likelihood estimates of the parameters.

The seven-day weighed food record was split into two parts (the first four and second three days) to provide two sets of measurements. It was assumed that the random errors between

measurements were unrelated. Figure 7.3 shows the path model of the parameters used in the method of Kaaks and co-workers (1994b).



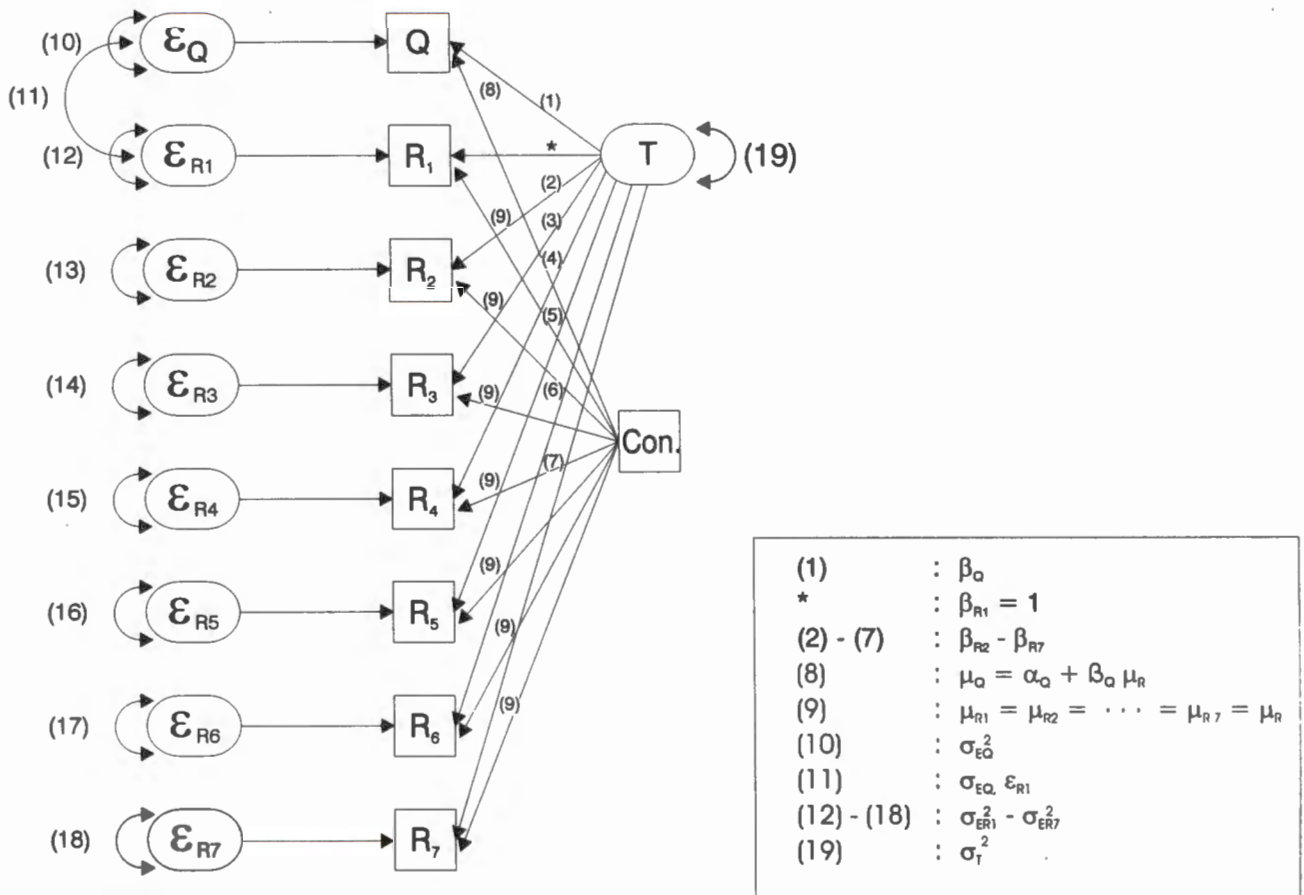
WHERE:

- observed (manifest) variables
- latent (non-observed) variables
- structural relation
- covariances / variance

R_1 = Reference measure 1 (first four days of weighed food record)
 R_2 = Reference measure 2 (second three days of weighed food record)
 Q = Quantitative food frequency questionnaire
 T = True intake
 σ^2_{ϵ} = Variance of random errors
 ϵ = Random error
 β = Proportional bias
 μ_Q = Mean of quantitative food frequency questionnaire
 μ_{R1-R2} = Mean of reference measures 1-2.

Figure 7.3: Path model of parameters used in the method of Kaaks *et al.* (1994b).

In an attempt to improve the correlation between the QFFQ and weighed record, each day was treated as a separate entity thus providing seven variables for the seven-day weighed record (Figure 7.4) or five variables for the five-day weighed record

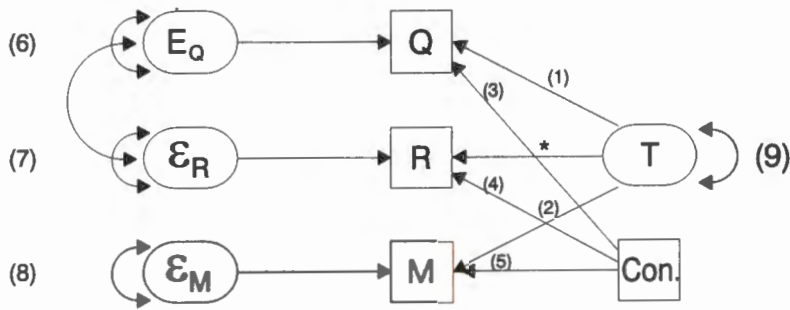


$R_1 - R_7$ = Reference measure, days 1 to 7 of the seven-day weighed food record
 Q = Quantitative food frequency questionnaire
 T = True intake
 σ_{ϵ}^2 = Variance of random errors
 ϵ = Random error
 β = Proportional bias
 μ = Mean

Figure 7.4: Path model of variables adapted from Kaaks *et al.* (1994b).

7.2.4.2 Inclusion of a biological marker

The inclusion of a third unrelated measurement, in the present study urinary protein and BMR, can be used to further describe the relationship between the QFFQ and true intakes. The assumption that the random errors are independent for each pair of measurements is thus more likely to be valid (Kaaks *et al.*, 1994b). The use of a biological marker helps to provide a better estimate of the relation between the QFFQ and the true intake than does the use of the QFFQ and weighed records alone (Kaaks *et al.*, 1994b). The relations between parameters are shown schematically in Figure 7.5.



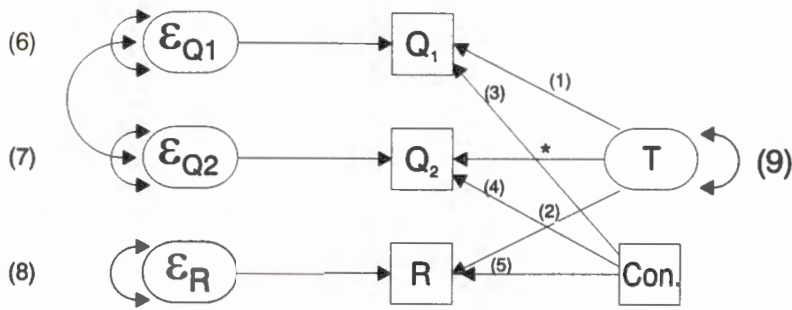
- | | |
|-------|------------------------------------|
| (1) : | β_o |
| * : | $\beta_R = 1$ |
| (2) : | β_m |
| (3) : | $\mu_o = \alpha_o + \beta_o \mu_m$ |
| (4) : | μ_R |
| (5) : | μ_m |
| (6) : | σ_{eQ}^2 |
| (7) : | σ_{eR}^2 |
| (8) : | σ_{eM}^2 |
| (9) : | σ_1^2 |

M = Biological marker
 R_2 = Reference measure (seven-day weighed food record)
 Q = Quantitative food frequency questionnaire
 T = True intake
 $\sigma^2 e$ = Variance of random errors
 e = Random error
 β = Proportional bias
 μ = Mean

Figure 7.5: Path model of parameters used with the inclusion of the biological marker.

For protein, the above model was applied to the results of 46 subjects for whom QFFQ, seven-day weighed records and urinary nitrogen values were available. As the BMR could be calculated for all subjects in the validity sample, the use of BMR as a biomarker was applied to 74 subjects.

In a further adaption of the model of Kaaks *et al.* (1994b), the biomarker was replaced by the values obtained from the second administration of the QFFQ. Only 27 subjects in the validation sample had taken part in the reproducibility study. Although this number might be too small to show definitive results it was decided to apply this model to total protein to see if such an application was feasible (Figure 7.6)



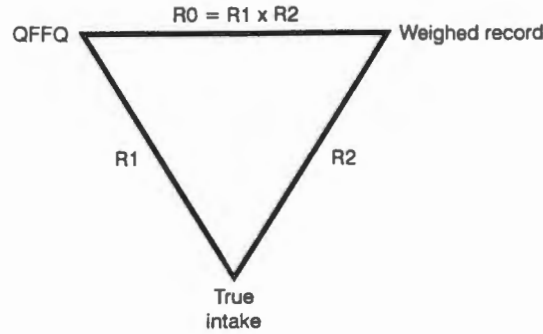
(1) :	β_o
* :	$\beta_R = 1$
(2) :	β_R
(3) :	$\mu_o = \alpha_o + \beta_o \mu_m$
(4) :	μ_{R1}
(5) :	μ_{R2}
(6) :	σ_{eQ}^2
(7) :	σ_{eR}^2
(8) :	σ_{eM}^2
(9) :	σ_T^2

R = Reference measure (seven-day weighed food record)
 Q₁ = First administration of quantitative food frequency questionnaire
 Q₂ = First administration of quantitative food frequency questionnaire
 T = True intake
 σ^2_e = Variance of random errors
 e = Random error
 β = Proportional bias

Figure 7.6: Path model of parameters in the model using the second administration of the QFFQ

7.2.5 Estimation of the correlation between intakes from the quantitative food frequency questionnaire and weighed records and the true intake

As pointed out in the previous section (7.2.4) although the seven-day weighed record has been used as representing the 'true' dietary intake of an individual, it is itself subject to both inter and intra-individual errors. Therefore, in interpreting the results of a validation study, these errors must be taken into account. Beaton (1991) described a procedure to estimate the variance components by examining the correlations between components. Figure 7.7 depicts the relationships among the QFFQ (the test method), the weighed record (reference method) and the true, but unknown, intake.



QFFQ= Quantitative food frequency questionnaire

R_0 = Correlation between intake from quantitative food frequency questionnaire and weighed record

R_1 = Correlation between intake from quantitative food frequency questionnaire and true intake

R_2 = Correlation between intake from weighed record and true intake

Figure 7.7: Observed and estimated correlations between the QFFQ, weighed record and true (unknown) intake (Beaton, 1991).

With reference to the above figure, R_0 , the correlation between the QFFQ and the weighed record can be directly estimated (7.2.1.3). R_2 , the correlation between the weighed record and the true intake, can be estimated from the method of Dunn (1989) using the following formulae:

$$\text{Correlation(Ref, True)} = R_2 = (r_{R,1})^{-1/2}$$

where Ref is the weighed record and $r_{R,1}$ is the reliability of an individual weighed record measurement (also known as the intra-subject correlation)

$$r_{R,1} = (S_B^2 - S_W^2) / (S_B^2 + (k-1) S_W^2)$$

where S_B^2 = between subject mean square; S_W^2 = within subject mean square; k = number of repetitions of weighed record.

The reliability of the mean of k reference measurements, i.e. of seven weighed record measurements is given by:

$$r_{R,k} = k r_{R,1} / (1 + (k-1)r_{R,1})$$

Returning to Figure 7.7, R_2 is estimated from the method of Dunn (1989). Thus R_1 , the correlation between the QFFQ and the true intake ($\hat{\rho}(Q,T)$) can be estimated from:

$$R_1 = R_0 / R_2.$$

7.3 RESULTS

7.3.1 Seven-day weighed record

7.3.1.1 Sample description

Of the total of 85 subjects recruited to complete the seven-day weighed record, 74 (87%) returned usable records. Reasons for records not being usable were: record not completed at all (3), insufficient information on types and amounts of foods given (3), record only completed for part of the seven days (3) and subjects could not be traced to collect the record (2).

Tables 7.1 and 7.2 show the composition of the sample according to gender and stratum of urbanisation. As pointed out in the Methods section (7.2.1.1), no subjects could be recruited from the farm worker stratum. Also, although an attempt was made to have all strata of urbanisation represented in the sample, the sample was not deliberately stratified. The percentage of subjects from the rural stratum (11%) was significantly lower than the percentage of subjects from the rural stratum in the main study (26%; $P < 0.05$) while the percentage from the middle class urban stratum (55%) was significantly higher than the main study sample (24%; $P > 0.05$). With regard to gender, there was a significantly higher percentage of women in the validation sample (80%) than in the main study sample (62%; $P < 0.05$). Thus, there may be considerable bias in the composition of the sample with regard to strata of urbanisation and gender and the results must be interpreted with this in mind. There were no significant differences, however, in the composition of the validation sample and the main study sample with regard to age and body mass index ($P > 0.05$).

By far the majority (80%) of subjects were females and most of the subjects (55%) came from the middle class urban stratum. These were the subjects who showed the most interest in the study as well as having the ability to complete the weighed record.

Table 7.1: Distribution of gender according to stratum of urbanisation (N=74)

Stratum	Males		Females		Total	
	N	%	N	%	N	%
Rural	0	0	8	10,8	8	10,8
Informal settlement	2	2,7	12	16,2	14	18,9
Middle class urban	7	9,5	34	45,9	41	55,4
Upper class urban	6	8,1	5	6,7	11	14,9
Total	15	20,3	59	79,6	74	100

Unfortunately, age groups were not evenly distributed across strata of urbanisation (Table 7.2). The middle class urban strata contained the highest number of young people (younger than 25 years of age) most of whom were students from Mmabatho and Ga-Rankuwa. All the rural subjects were older than 25 years with seven of the eight subjects being older than 35 years. Although the mean age of the females in the rural stratum was on average 14 years older than that of the other strata, it was only significantly higher than the mean age of the male, middle class urban stratum ($P<0,05$).

Table 7.2 Distribution of age according to strata of urbanisation (N=74)

Stratum	Age (years)							
	15 - 24,9		25 - 34,9		35 - 64,9		Total	
	N	%	N	%	N	%	N	%
Rural	0	0	1	1,4	7	9,5	8	10,8
Informal settlement	4	5,4	8	10,8	2	2,7	14	18,9
Middle class urban	15	20,3	11	14,9	15	20,3	41	55,4
Upper class urban	1	1,4	5	6,7	5	6,7	11	14,9
Total	20	27,1	25	33,7	29	39,2	74	100

Table 7.3: Mean ($\pm$ SD) age and body mass index of females and males (N=74).

Stratum	Age (years)				**BMI			
	Males		Females		Males		Females	
	Mean	*SD	Mean	*SD	Mean	*SD	Mean	*SD
Rural	-		44,5	10,4	-		27,4	4,0
Informal settlement	28,5	6,4	30,3	10,4	21,0	3,7	23,6	3,2

Middle class urban	24,0	2,0	33,3	11,1	21,3	2,0	28,7	6,4
Upper class urban	33,0	7,8	35,4	10,4	22,5	4,0	28,0	6,0
Total	28,2	8,6	34,4	11,4	21,8	2,9	27,4	5,8

*SD=Standard deviation; **BMI=body mass index (weight (kg)/height(m)²)

The mean BMI of the males was on the lower side of normal (22 kg/m²) while that of the females could be classified as overweight (27 kg/m²). Although the BMI of the females from the informal settlement stratum was considerably lower than that of the other strata, there were no significant differences between the mean BMI of any of the strata ($P>0,05$).

7.3.1.2 Comparison of nutrient intakes of the quantitative food frequency questionnaire with the seven-day weighed record

(a) Spearman rank correlation coefficients

Although there is some argument as to the usefulness of correlation coefficients in the determination of the validity of dietary intake measurement instruments (Bland & Altman, 1989; Kaaks *et al.*, 1994b), historically these have been used and are thus presented here both for comparative purposes with other studies and for comparison with other methods of statistical analysis. Tables 7.4 to 7.7 present the Spearman rank correlation coefficients between the mean reported nutrient intakes of the seven-day weighed record and the reported intakes from the QFFQ for the whole sample and for subgroups based on gender, stratum of urbanisation, age group and BMI.

Table 7.4: Spearman rank correlation coefficients between seven-day weighed record and quantitative food frequency questionnaire (N=74)

Nutrient	Entire sample N=74		Males N=15		Females N=59	
	Spearman R	†95% CI	Spearman R	†95%CI	Spearman R	†95% CI
Energy	0,311	0,089-0,504**	0,775	0,436-0,921***	0,178	-0,082-0,415
Total protein	0,295	0,071-0,490*	0,840	0,575-0,945***	0,178	-0,082-0,415
Total carbohydrate	0,305	0,082-0,499**	0,639	0,188-0,867***	0,229	-0,029-0,458

	Entire sample N=74		Males N=15		Females N=59	
Nutrient	Spearman R	†95% CI	Spearman R	†95% CI	Spearman R	†95% CI
Total fat	0,250	0,023-0,453*	0,611	0,144-0,856*	0,144	-0,116-0,386
Cholesterol	0,232	0,004-0,437*	0,543	0,043-0,826*	0,159	0,101-0,399
Fibre	0,137	0,095-0,354	0,588	0,108-0,846*	0,013	-0,244-0,268
Calcium	0,237	0,009-0,442*	0,432	-0,103-0,773	0,210	-0,049-0,442
Iron	0,198	-0,032-0,408	0,801	0,490-0,931***	0,110	0,150-0,356
Vitamin A	0,216	-0,013-0,424	0,411	-0,128-0,763	0,177	-0,083-0,414
Vitamin C	0,597	0,427-0,726***	0,206	-0,342-0,650	0,662	0,489-0,785***
Alcohol	0,529	0,342-0,676***	0,730	0,348-0,904**	0,373	0,129-0,574***

Level of significance: * $P<0,05$; ** $P<0,01$; *** $P<0,001$; †95% CI: 95% confidence interval

There appear to be weak to moderate correlations between the two instruments for all nutrients for the sample as a whole. Nevertheless the Spearman rank coefficients are significant ($P<0,05$) for all nutrients except fibre, iron and vitamin A ($P>0,05$). The strongest correlations were for vitamin C and alcohol while fibre showed the weakest correlation. The Spearman rank correlation coefficients for the males appear considerably stronger than for the females especially for energy, protein and iron which gave strong significant positive correlation coefficients ($\geq 0,8$) ($P<0,001$). The correlation coefficient for energy, protein, iron and fibre for males were significantly stronger than those of the females ($P<0,05$). Differences obtained for the other nutrients were not significant ($P>0,05$).

In order to have sufficient numbers in the subgroups according to strata of urbanisation for calculation and comparison of Spearman rank correlation coefficients, the rural and informal settlement strata and the middle and upper class urban strata were combined. However, the number of subjects in the latter class is considerably greater than the former, which may affect the results.

Table 7.5: Spearman rank correlation coefficients between seven-day weighed record and quantitative food frequency questionnaire according to stratum of urbanisation (N=74)

	Rural and informal settlement N=22		Middle and upper class urban N=52	
Nutrient	Spearman R	†95% CI	Spearman R	† 95% CI
Energy	0,141	-0,289-0,531	0,380	0,119-0,592**
Total protein	0,256	-0,186-0,612	0,314	0,063-0,528*
Total carbohydrate	0,041	-0,387-0,455	0,397	0,139-0,604**
Total fat	0,085	-0,349-0,489	0,296	0,025-0,526*
Cholesterol	0,453	0,039-0,374*	0,139	-0,139-0,397
Fibre	0,043	-0,386-0,456	0,147	-0,131-0,404
Calcium	-0,133	-0,525-0,306	0,394	0,136-0,602**
Iron	0,284	-0,156-0,630	0,156	-0,122-0,411
Vitamin A	0,278	-0,163-0,626	0,168	-0,110-0,422
Vitamin C	0,524	0,131-0,775*	0,566	0,347-0,727***
Alcohol	0,592	0,227-0,811**	0,531	0,302-0,702***

Level of significance: * $P<0,05$; ** $P<0,01$; *** $P<0,001$; †95% CI: 95% confidence interval

From Table 7.5, it appears that the middle and upper class urban subjects achieved better correlations between the weighed record and the QFFQ than did the informal settlement and rural subjects. Spearman rank correlation coefficients were significant for energy, total protein, total carbohydrate, total fat, calcium, vitamin C and alcohol for the middle and upper class subjects whereas only those of cholesterol, vitamin C and alcohol were significant for the rural and informal settlement subjects. Despite these apparent differences, only the correlation coefficient for calcium differed significantly between the two groups ($P<0,05$).

Table 7.6: Spearman rank correlation coefficients between seven-day weighed record and quantitative food frequency questionnaire according to age groups (N=74)

Nutrient	Age group (years)					
	15 - 24,9 N=20		25 - 34,9 N=25		35 - 64,9 N=29	
	¶R	† 95% CI	¶R	† 95% CI	¶R	† 95% CI
Energy	0,438	-0,006-0,738	0,008	-0,338-0,402	0,251	-0,127-0,565
Total protein	0,398	-0,054-0,715	0,225	-0,187-0,570	0,106	-0,271-0,455
Total carbohydrate	0,275	-0,191-0,640	0,168	-0,243-0,528	0,239	-0,140-0,557
Total fat	0,314	-0,149-0,664	-0,124	-0,495-0,285	0,324	-0,048-0,617
Cholesterol	0,199	-0,267-0,590	0,231	-0,181-0,574	0,325	-0,047-0,618
Fibre	0,343	0,117-0,682	0,158	0,253-0,521	-0,054	-0,319-0,412
Calcium	0,511	0,089-0,778*	0,067	0,337-0,450	0,140	-0,239-0,482
Iron	0,164	-0,30-0,565	0,158	-0,253-0,521	0,281	-0,095-0,587
Vitamin A	0,543	0,132-0,795*	0,048	-0,354-0,435	0,084	-0,291-0,437
Vitamin C	0,698	0,370-0,871***	0,533	0,175-0,767	0,581	0,273-0,781
Alcohol	-0,100	0,358-0,520	0,823	0,634-0,919**	0,460	0,112-0,707

Level of significance: *P<0,05; ** P<0,01; *** P<0,001; †95% CI: 95% confidence interval

¶R: Spearman rank correlation coefficient.

The sizes of the subgroups based on age (Table 7.6) were the only divisions which gave fairly equal numbers in the subgroups thus making comparisons more meaningful. The youngest age group showed stronger correlations than the two older age groups for energy, total protein, total carbohydrate, fibre, calcium, vitamin A and vitamin C while the age group older than 35 years showed the strongest correlations for total fat, cholesterol and iron. However, none of these differences were statistically significant ($P>0,05$). On the other hand, the Spearman rank correlation coefficient for alcohol for the 25 to 34,9-year age group was significantly higher than both that of the younger age group ($P<0,001$) and the older age group ($P<0,05$). Of note is the very weak negative correlation coefficient for alcohol of the 15 to 24,5-year age group, as thus far alcohol had shown strong correlations for all analyses.

Table 7.7: Spearman rank correlation coefficients between seven-day weighed record and quantitative food frequency questionnaire according to body mass index (N=74)

Nutrient	Body mass index (kg/m ²)					
	< 21 N=12		21 - 26,9 N=35		≥27 N=27	
	¶ R	†95% CI	¶ R	†95% CI	¶ R	†95% CI
Energy	0,021	-0,560-0,588	0,369	0,041-0,625*	0,281	-0,111-0,597
Total protein	0,063	0,530-0,615	0,429	0,112-0,667*	0,223	-0,172-0,552
Total carbohydrate	- 0,224	-0,707-0,402	0,402	0,079-0,648*	0,335	-0,052-0,634
Total fat	0,203	-0,420-0,696	0,261	-0,079-0,547	0,238	-0,156-0,567
Cholesterol	0,266	0,363-0,729	0,295	-0,042-0,572	0,061	-0,327-0,431
Fibre	-0,102	-0,639-0,501	0,286	-0,052-0,565	-0,042	-0,415-0,344
Calcium	0,252	-0,376-0,722	0,032	-0,304-0,361	0,334	-0,053-0,634
Iron	-0,047	-0,542-0,605	0,310	-0,026-0,583	0,079	-0,310-0,446
Vitamin A	0,608	0,052-0,876*	0,186	-0,157-0,489	0,104	-0,287-0,466
Vitamin C	0,555	-0,028-0,856	0,551	0,267-0,747***	0,723	0,473-0,865***
Alcohol	0,620	0,072-0,881*	0,778	0,600-0,882***	0,282	-0,111-0,590

Level of significance: *P<0,05; ** P<0,01; *** P<0,001; ¶ R: Spearman rank correlation coefficient; †95% CI: 95% confidence interval

Since the sizes of the subgroups based on BMI were disproportionate, it is difficult to say whether the apparent differences in correlation coefficients are true reflections of the validity of the QFFQ or whether they are merely due to the small sample size especially of the group with BMI less than 21 kg/m². The most (five out of 11) significant correlation coefficients were achieved by the subgroup with BMI in the normal range. However, this was also the largest subgroup. The only correlation coefficient that differed significantly among subgroups was that of alcohol which was significantly higher for the 21- 26,9 kg/m² group than for the group with BMI greater than 27 kg/m² (P<0,01).

(b) Paired t-tests

Since the numbers of subjects in the subgroups for age, urbanisation and BMI were small and uneven, and also, since the Spearman rank correlation coefficients showed few differences, the remaining results are presented for the validation sample as a whole and for males and females.

Table 7.8: Mean, standard deviation and differences between intakes of seven-day weighed record and quantitative food frequency questionnaire (N=74)

		Entire sample N=74				Males N=15				Females N=59			
Nutrient		Mean	SD	Diff ††%	95% CI	Mean	SD	Diff ††%	95% CI	Mean	SD	Diff ††%	95% CI
Energy (kJ)	*Q *R	8810 9095	3030 2685	285 3,2	-488- 1058	9143 11156	3222 3041	2013 19,8	894- 3132**	8725 8572	2976 2338	-153 -1,8	-1059- 753
Total protein (g)	Q R	67,4 77,2	22,0 26,2	9,8 13,6	3,2- 16,4**	70,9 97,4	23,4 31,0	26,5 31,5	17,9- 35,1---	66,5 72,1	21,8 22,4	5,6 8,1	-2,2- 13,4
Total carbohydrate (g)	Q R	302,2 299,0	110,9 94,4	- 3,2 - 1,1	-31,5- 25,1	308,0 353,4	131 110	45,4 13,7	-17,0- 108	300,7 285,1	106 84,2	-15,6 -5,3	-47,4- 16,2
Total fat (g)	Q R	69,8 73,0	29,0 25,8	3,2 4,5	-4,7- 11,1	72,4 92,8	26,7 28,8	20,4 24,7	6,8- 34,0**	69,1 67,9	29,7 22,6	- 1,2 - 1,8	-10,2- 7,8
Cholesterol (g)	Q R	291,6 300,4	161,6 144,6	8,8 3,0	-36,4- 54,0	309,0 355,2	133 146	46,2 13,9	-30,5- 123	287,2 286,5	169 142	- 0,7 - 0,2	-54,6- 53,2
Fibre (g)	Q R	19,3 20,4	8,1 7,8	1,1 5,5	-1,0- 3,2	20,5 25,8	9,8 11,0	5,3 22,9	1,0- 9,6*	19,0 19,1	7,7 6,2	0,1 0,5	-2,3- 2,5
Calcium (mg)	Q R	485,6 537,5	227,8 238,1	51,9 10,1	-14,6- 118	518,6 653,8	243 234	135 23,1	28,3- 242*	477,2 507,9	225 232	30,7 6,2	-48,5- 110
Iron (mg)	Q R	9,7 10,2	3,6 3,7	0,5 5,0	-0,6- 1,6	9,3 12,3	3,0 3,6	3,0 27,8	1,8- 4,2---	9,8 9,6	3,8 3,5	- 0,2 - 2,1	-1,5- 1,1
Vitamin A (RE)	Q R	924,7 1058	711,3 1543	133 13,4	-191- 457	754,7 531,6	562 391	-223 -34,7	-594- 148	967,9 1191	742 1694	223 20,7	-173- 619
Vitamin C (mg)	Q R	81,7 69,2	87,4 58,9	-12,5 -16,6	-31,9- 6,9	71,6 56,4	55,1 27,1	-15,2 -23,8	-48,2- 17,8	84,2 72,4	94,0 64,3	-11,8 -15,1	-35,1- 11,5
Alcohol (g)	Q R	1,3 2,7	3,7 6,1	1,4 70	0,1- 2,7*	3,8 6,2	6,3 8,9	2,4 48,0	-2,1- 6,9	0,7 1,8	2,3 4,9	1,1 88	-0,2- 2,4

*Q=quantitative food frequency questionnaire; R=seven-day weighed records; ‡95%

CI=95% confidence interval; ¶SD=standard deviation; †Diff= mean intake (seven-day weighed record)-mean intake (QFFQ); ††%=(mean intake (seven-day weighed record)-mean intake (QFFQ))/(mean intake (seven-day weighed record)+mean intake (QFFQ))/2*100

Level of significance: *P<0,05; ** P<0,01; *** P<0,001

On the basis of the sample means, it appears from Table 7.8 that intakes recorded by the QFFQ and the mean intakes obtained from the weighed records were similar. For the sample as a whole, the only significant differences were for total protein (P<0,01) and for alcohol (P<0,05). There were no significant differences for the females, but differences between means were significant for six nutrients (energy, protein, total fat, fibre, calcium and iron) for the males (P<0,05). The QFFQ seems to underestimate intakes slightly for most nutrients, except for total carbohydrate

(for the whole sample and females), total fat, cholesterol, iron (females), vitamin A (males) and vitamin C (whole sample, males and females).

Tables 7.4 (Spearman rank correlation coefficients) and 7.8 (differences between means) illustrate the danger of drawing conclusions about validity based only on one type of statistical analysis. From Table 7.4, for the females, there appears to be little correlation between the intakes obtained from the QFFQ and the weighed records, thus the validity of the QFFQ could be questioned. However, according to the sample means (Table 7.8), the two methods of dietary data collection give similar results. Some nutrients show marked contrasts between the Spearman rank correlation coefficient and the difference between means. For example, for the whole sample, there are very weak, non-significant correlations for fibre (0,14) and iron (0,2) but only one gramme difference between means for fibre and 0,5 g for iron.

- (c) Agreement between the quantitative food frequency questionnaire and the seven-day weighed record (Bland-Altman plots)

The Bland-Altman method was used to assess the level of agreement and the presence of proportional bias between the reported nutrient intakes obtained from the QFFQ and the mean of the seven-day weighed records. None of the plots showed proportional bias indicated by a significant Spearman rank correlation coefficient. For all nutrients, agreement as indicated by the percentage of subjects within the limits of agreement, was above 90% and for three nutrients (total fat, fibre and vitamin C), above 95%. Table 7.9 summarises the results of the Bland-Altman plots for the energy and the nutrients. Figure 7.8 shows the Bland-Altman plot for energy and Figure 7.9 the plot for vitamin A.

Table 7.9: Summary of agreement between seven-day weighed food record and quantitative food frequency questionnaire (N=74)

Nutrient	Limits of agreement		Outside limits of agreement N	% Agreement	Spearman R	†95% CI	*sd/sm
	Lower	Upper					
Energy (kJ)	-6257	6827	4	94,6	- 0,06	-0,285-0,171	1,4
Total protein (g)	- 46,5	66,1	5	93,2	0,11	-0,112-0,330	1,5
Total carbohydrate (g)	- 247	241	4	94,6	- 0,18	-0,392-0,051	1,6
Total fat (g)	- 63,3	69,7	3	95,9	- 0,12	-0,339-0,112	1,7
Cholesterol (mg)	- 373,6	391,0	6	91,9	- 0,11	-0,330-0,122	1,0
Fibre (g)	- 16,9	19,1	2	97,3	0,001	-0,228-0,229	1,4
Calcium (mg)	- 511,5	613,0	4	94,6	0,02	-0,209-0,247	1,6
Iron (mg)	- 8,8	9,6	4	94,6	- 0,03	-0,257-0,200	1,7
Vitamin A (RE)	-2550	2822	4	94,6	0,05	-0,181-0,275	1,4
Vitamin C (mg)	-177,0	151,0	3	95,9	0,11	-0,122-0,330	1,4
Alcohol (g)	- 13,1	10,1	5	93,2	0,002	-0,227-0,230	1,6

†95% CI: 95% confidence interval; *sd/sm: standard deviation of the differences / standard deviations of the means

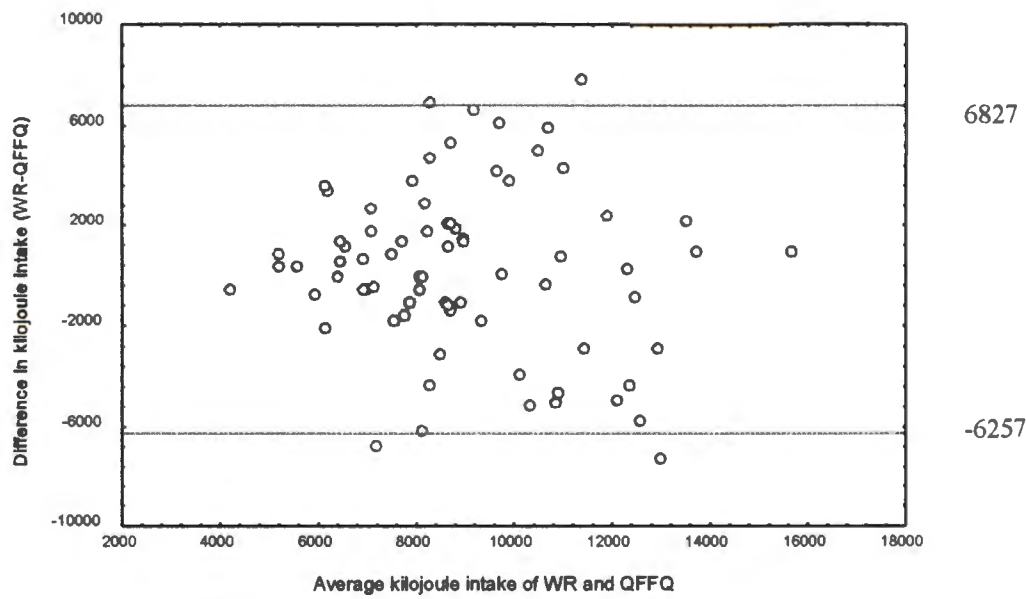


Figure 7.8: Bland-Altman plot for energy

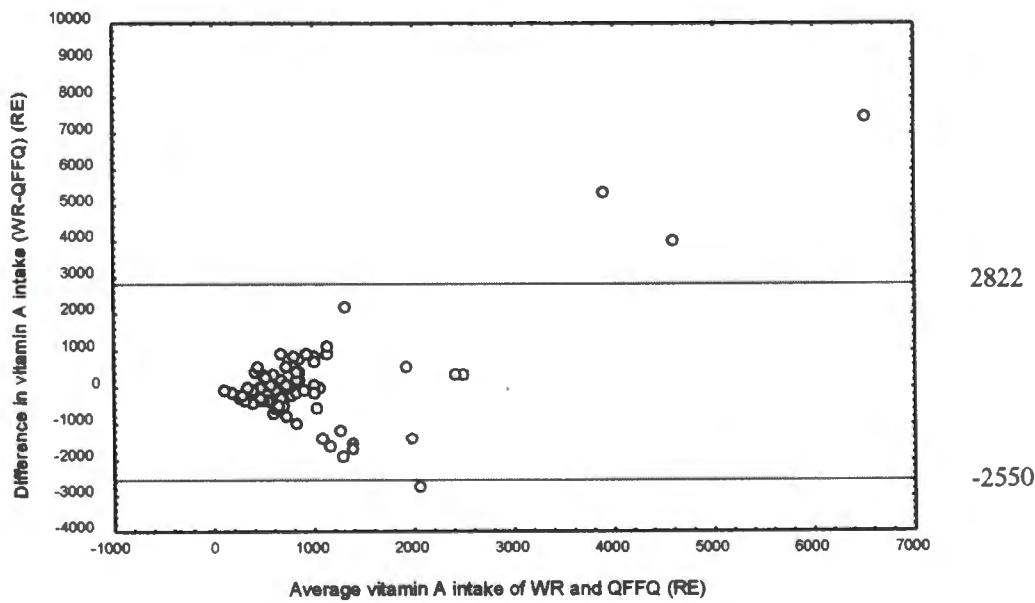


Figure 7.9: Bland-Altman plot for vitamin A

The above two plots illustrate the differences in patterns of agreement of various nutrients. For energy, there is a fairly even spread of intakes from low (4000 kJ) to high (15 500 kJ), with most points being between 6000 and 12000 kJ. There appears to be a tendency for the differences to get bigger as the mean intake increases. However, this is not consistent (the difference for the highest intake is less than 1000 kJ) and the Spearman rank correlation coefficient between the mean and the differences of intakes is not significant ($P>0,05$). In contrast, the plot for vitamin A is an example of the case where the majority of reported intakes on both the QFFQ and the seven-day weighed record are low. Most points are concentrated between zero and 1000 RE. Several high intakes also show large differences, but these are still within the limits of agreement. There are three outliers with mean intakes greater than 3000 RE and large differences where the intakes reported from weighed record were more than 4000 RE greater than that of the QFFQ. This could be explained by high intakes of vitamin A rich foods during the recording period.

(d) Comparison of quintile distribution between seven-day weighed record and quantitative food frequency questionnaire

In order to determine whether the QFFQ would classify subjects into the same positions within the distribution as the seven-day weighed record, the distributions obtained from both methods were divided into quintiles and positions of subjects in each distribution compared, as was done for the reproducibility study (6.3.2.4). Table 7.10 presents the cumulative frequency of subjects classified into the same and adjacent quintiles of the two distributions for the entire sample and for the males and females.

Table 7.10: Classification of subjects into the same and adjacent quintiles of the distribution for the QFFQ and the seven-day weighed food record (N=74)

	Entire sample (N=74)				Males (N=15)				Females (N=59)			
Nutrient	Cumulative %				Cumulative %				Cumulative %			
	*S	±1	±2	±3	*S	±1	±2	±3	*S	±1	±2	±3
Energy	32	69	93	100	33	80	93	100	27	66	93	100
Protein	31	78	93	98	33	93	100	100	31	75	92	99
Carbohydrate	34	77	93	100	47	80	93	100	31	76	93	100
Fat	36	74	96	100	40	67	100	100	34	71	95	100

	Entire sample (N=74)				Males (N=15)				Females (N=59)			
Nutrient	Cumulative %				Cumulative %				Cumulative %			
	*S	±1	±2	±3	*S	±1	±2	±3	*S	±1	±2	±3
Cholesterol	38	80	92	99	47	93	93	100	39	76	91	98
Fibre	30	74	96	100	40	67	94	100	27	76	96	99
Calcium	43	88	98	100	40	93	100	100	44	86	96	99
Iron	28	73	95	99	33	73	99	100	27	72	92	97
Vitamin A	57	85	93	98	66	87	94	100	54	85	93	98
Vitamin C	66	95	95	96	66	100	100	100	66	93	93	95
Alcohol	79	91	96	99	53	73	93	100	86	95	97	99

*S = percentage of subjects classified into the same quintile; ±1, ±2, ±3 cumulative percentage of subjects classified into the first, second or third adjacent quintiles of the distributions of the seven-day weighed record and the QFFQ

The highest number of subjects classified into the same quintile for both distributions was for alcohol (79%). Other nutrients for which more than 50% of subjects were classified into the same quintile were vitamin A (57%) and vitamin C (66%). Energy showed the poorest agreement with only 32% of subjects being classified into the same quintile and 37% into adjacent quintiles. Less than 40% of subjects were classified into the same quintile for protein, carbohydrate, fat, cholesterol, fibre and iron. When adjacent quintiles were included, more than 70% of subjects were in similar quintiles for both distributions (except for energy).

7.3.1.3 Comparison of food group intakes of the quantitative food frequency questionnaire with the seven-day weighed record

The same food groups were used for comparison as for the reproducibility study. Results of the food group analyses will only be presented for the sample as a whole.

(a) Spearman rank correlation coefficients

The Spearman rank correlation coefficients for the various food groups are presented in Table 7.11.

Table 7.11: Spearman rank correlations for food groups between the quantitative food frequency questionnaire and the seven-day weighed record (N=74)

Food group	Entire sample N=74		Males N=15		Females N=59	
	ρ R	†95% CI	ρ R	†95% CI	ρ R	†95% CI
Milk	0,142	-0,089-0,359	- 0,290	-0,699-0,261	0,186	-0,074-0,422
Meat	0,352	0,134-0,537**	0,539	0,037-0,824*	0,218	-0,040-0,449
Fish	0,128	-0,104-0,346	- 0,030	-0,490-0,534	0,211	-0,048-0,443
Legumes	0,108	-0,124-0,328	0,175	-0,370-0,631	0,0004	-0,256-0,256
Eggs	0,138	-0,093-0,355	0,079	-0,452-0,568	0,154	-0,106-0,395
Fruit	0,379	0,165-0,559*	0,314	-0,236-0,712	0,393	0,152-0,590**
Vegetables	0,409	0,199-0,583**	0,472	-0,053-0,793	0,422	0,186-0,612**
Maize meal	0,564	0,385-0,702***	0,612	0,145-0,886*	0,544	0,335-0,702***
Rice	0,111	-0,121-0,331	0,019	-0,498-0,526	0,109	-0,157-0,355
Samp	0,100	-0,132-0,321	0,487	-0,034-0,800	- 0,011	-0,266-0,246
Bread	0,248	0,021-0,451*	0,337	-0,212-0,724	0,195	-0,064-0,430
Other cereals	0,328	0,108-0,518**	- 0,298	-0,255-0,703	0,404	0,165-0,598**
Fat	0,21	-0,019-0,419	- 0,440	-0,777-0,093	0,310	0,059-0,524*
Sugar	0,562	0,383-0,701***	0,505	-0,010-0,808*	0,540	0,329-0,699***

Level of significance: *P<0,05; ** P<0,01; *** P<0,001; †95% CI: 95% confidence interval

ρ R: Spearman rank correlation coefficient.

Significant Spearman rank correlation coefficients were obtained for half (seven of 15) of the food groups for the sample as a whole. Of note is that those food groups which make substantial contributions to the diet (maize meal, cereals and sugar) show significant correlation coefficients. On the other hand, meat, fruit, vegetables and bread which are consumed in relatively small amounts also showed significant correlation coefficients. The validity based on Spearman rank correlation coefficients for food groups does not seem to be as high as that based on nutrients (Table 7.4) where 73% (eight of 11 nutrients) had significant correlation coefficients. However, the correlation coefficients calculated for the nutrients and for the food groups confirm each other. For example, the Spearman R for vitamin C is significant, as is that for fruit and vegetables, the main dietary sources of vitamin C; the correlation coefficient for total carbohydrate is significant as is that of most of the carbohydrate rich food groups (fruit, maize meal, bread, other cereals and sugar) and the correlation coefficients of both protein and the meat

group are significant. By contrast, although Spearman R for fat as the nutrient is significant, for fat as a food group it is not.

(b) Comparisons between reported mean intakes of food groups between seven-day weighed records and quantitative food frequency questionnaire

The results of the paired t-test for food group intakes between the means of the QFFQ and the means of the seven-day weighed food records are given in Table 7.12 for the total sample, males and females.

Table 7.12: Mean, standard deviation and differences for food groups between the quantitative food frequency questionnaire and seven-day weighed food record (N=74).

Food group	Entire sample N=74				Males N=15				Females N=59			
	Mean	¶SD	†Diff ††%	‡95% CI	Mean	¶SD	†Diff ††%	‡95% CI	Mean	¶SD	†Diff ††%	‡95% CI
Milk (g) *Q *R	169,5 194,3	127,4 157,8	24,9 13,7	-67,6- 17,8	177,3 210,1	135 145	32,9 17,0	-54- 120	167,3 190,0	126 156	22,6 12,7	-27,5- 72,7
Meat (g) Q R	124,0 138,9	72,8 68,8	14,9 11,3	-34,5- 4,7	144,3 193,2	79,0 80,6	48,9 29,0	6,8- 91*	118,4 124,1	70,8 57,7	5,7 2,4	-40,9- 52,3
Fish (g) Q R	15,9 15,6	15,7 19,9	-0,3 -1,9	-5,9- 5,3	20,1 20,7	18,7 24,7	0,6 2,9	-16- 17,2	14,8 14,2	14,8 18,5	-0,6 -2,4	-6,5- 5,3
Legumes(g)Q R	29,8 23,0	36,7 28,5	-6,8 -25,8	-17,7- 4,1	12,9 8,9	18,4 13,8	-4,0 -18,3	-17,7- 9,7	34,5 26,8	39,1 30,3	-7,7 -25,1	-21,1- 5,7
Eggs (g) Q R	30,6 23,1	33,3 28,9	-7,5 -14,0	-16,1- 1,1	33,5 29,4	28,3 24,2	-4,1 -13,0	-23- 14,8	29,8 21,4	34,7 21,1	-8,4 -32,8	-18,4- 1,6
Fruit (g) Q R	198,2 138,4	169,1 117,3	-59,8 -35,5	-95,9- -24**	253,0 131,3	183 87,7	-122 -63,3	-209- -35**	183,2 140,3	164 125	-42,9 -26,6	-82,7- -3,1*
Vegetables Q (g) R	97,0 90,7	53,2 61,9	-6,3 -6,7	-19,7- 7,1	82,6 83,8	32,8 62,1	1,3 1,6	-29,3- 31,9	100,9 92,6	57,2 62,3	-8,3 -8,6	-23,6- 7,0
Maize meal Q (g) R	85,8 72,7	80,7 65,0	-13,1 -16,6	-33- 6,8	103,8 73,3	99,7 46,5	-29,9 -33,8	-81,0- 21,2	80,9 72,3	75,1 69,5	-8,5 -11,1	-30,5- 13,5
Rice (g) Q R	53,3 76,8	65,0 68,0	23,5 36,1	1,7- 45,3*	78,3 103,3	120 86,8	25,0 27,5	-62,6- 113	46,5 69,6	38,2 60,8	23,1 39,8	4,9- 41,3*
Samp (g) Q R	26,6 33,5	39,6 53,2	6,9 23,0	-8,5- 22,3	3,9 19,6	6,7 33,8	15,7 134	-2,3- 33,7	32,7 37,3	42,6 57,1	4,6 13,1	-14,5- 23,7
Bread (g) Q R	107,0 164,5	80,2 105,4	57,5 42,4	47,7- 67,3**	110,5 245,1	71,4 150	134 75,4	56- 212**	106,1 142,5	83,0 77,9	36,5 29,4	10,6- 62,4**

Food group	Entire sample N=74				Males N=15				Females N=59			
	Mean	¶SD	†Diff ††%	‡95% CI	Mean	¶SD	†Diff ††%	‡95% CI	Mean	¶SD	†Diff ††%	‡95% CI
Cereals (g) Q	43,9	88,3	-15,9	-36,1-	39,5	128	-29,1	-44,6-	45,1	75,7	-12,3	-30,8-
R	28,0	49,9	-44,2	4,3	10,5	23,2	-116	103	32,9	54,2	-31,5	6,2
Fat (g) Q	20,2	17,5	-3,7	-8,6-	18,5	22,8	- 7,6	-21,8-	20,6	16,0	- 2,6	-7,7-
R	16,4	14,1	-20,2	1,2	10,9	6,4	-51,7	6,6	17,9	15,2	-13,5	2,5
Sugar (g) Q	26,6	26,4	-8,8	-26,5-	16,4	12,1	- 1,7	-11,2-	29,4	28,5	-10,7	-17,8-
R	17,9	15,7	-39,6	-8,9**	14,7	17,9	- 5,5	7,8	18,7	15,2	-44,5	-3,6**

*Q=quantitative food frequency questionnaire; R=seven-day weighed records

¶SD=standard deviation; †Diff= mean intake (seven-day weighed record)-mean intake(QFFQ); ††%=(mean intake (seven-day weighed record)-mean intake (QFFQ))/(mean intake (seven-day weighed record)+mean intake (QFFQ))/2*100; ‡95%CI: 95% confidence interval; Level of significance: *P<0,05; ** P<0,01; *** P<0,001

Considering the results of the comparison of nutrient intakes (Table 7.8) it might be expected that the food intake reported from the seven-day weighed record would be higher than that recorded by the QFFQ. However, this is only true for five of the 14 food groups. Nevertheless, several food groups do show similar results to their main nutrient constituent. The intakes of both the milk group and calcium appear to be underestimated by the QFFQ, as are the meat and protein. In the case of both the fruit group and vitamin C, the QFFQ gave higher intakes than the seven-day weighed record. In the case of the carbohydrate rich food groups, some were underestimated by the QFFQ (rice, samp, bread) and others overestimated (fruit, maize meal, cereals and sugar). These varying results may have resulted in the mean intakes of carbohydrates reported for the two methods being virtually the same.

As for the Spearman rank correlation coefficient, a very important result was that of maize meal for which the difference in mean intakes from the QFFQ and the seven-day weighed record was not significant. Another finding of note is that the reported mean intakes of food groups consumed in relative small amounts such as fish, legumes and eggs showed small differences. In contrast, rice, also consumed relatively infrequently, showed a large difference (24 g) between mean obtained from the two methods.

- (c) Agreement of food groups between quantitative food frequency questionnaire and seven-day weighed food record (Bland-Altman plots)

A summary of the limits of agreement, percentage of agreement and Spearman rank correlation coefficients is shown in Table 7.13. The Bland-Altman plot for maize meal is shown in Figure 7.10 and that for sugar in Figure 7.11

Table 7.13: Summary of agreement between seven-day weighed food record and quantitative food frequency questionnaire according to food groups (N=74)

Food group	Limits of agreement		Observations outside limits of agreement N	% Agreement	Spearman R	†95% CI	*sd/sm
	Lower	Upper					
Milk (g)	-344	369	3	95,9	- 0,119	-0,338-0,113	1,7
Meat (g)	-155	185	2	97,3	- 0,027	-0,254-0,203	1,5
Fish (g)	- 49	49	4	94,6	0,207	-0,226-0,416	1,8
Legumes (g)	-101	87	8	89,0	-0,156	-0,371-0,075	2,0
Eggs (g)	- 82	67	5	93,2	-0,069	-0,293-0,162	1,8
Fruit (g)	-371	252	5	93,2	0,266	0,040-0,460*	1,3
Vegetables(g)	-122	109	2	97,3	0,135	-0,097-0,353	0,9
Maize meal(g)	-185	159	7	90,5	0,066	-0,165-0,290	1,5
Rice (g)	-165	212	4	94,6	0,397	0,185-0,573***	2,0
Samp (g)	-126	140	4	94,6	0,195	-0,035-0,405	2,0
Bread (g)	-174	289	4	94,6	0,167	-0,064-0,381	1,6
Cereals (g)	-190	159	3	95,9	-0,188	-0,399-0,042	1,6
Fat (g)	- 46	38	4	94,6	-0,113	-0,333-0,119	1,7
Sugar (g)	- 60	42	4	94,6	-0,319	-0,510--0,098**	1,5

†95% CI: †95% confidence interval; *sd/sm: standard deviation of the differences / standard deviation of the means

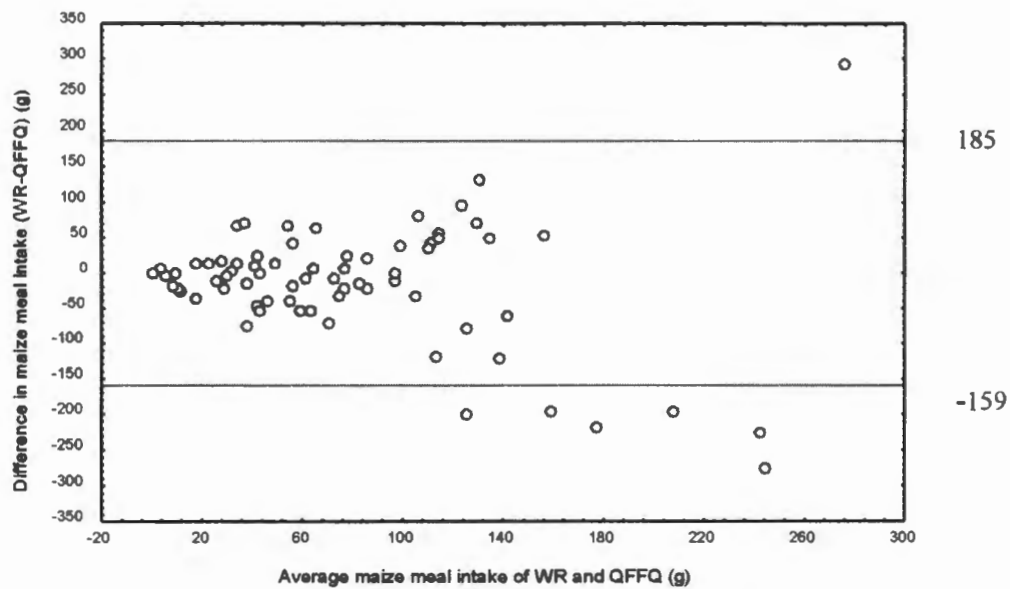


Figure 7.10: Bland-Altman plot for maize meal

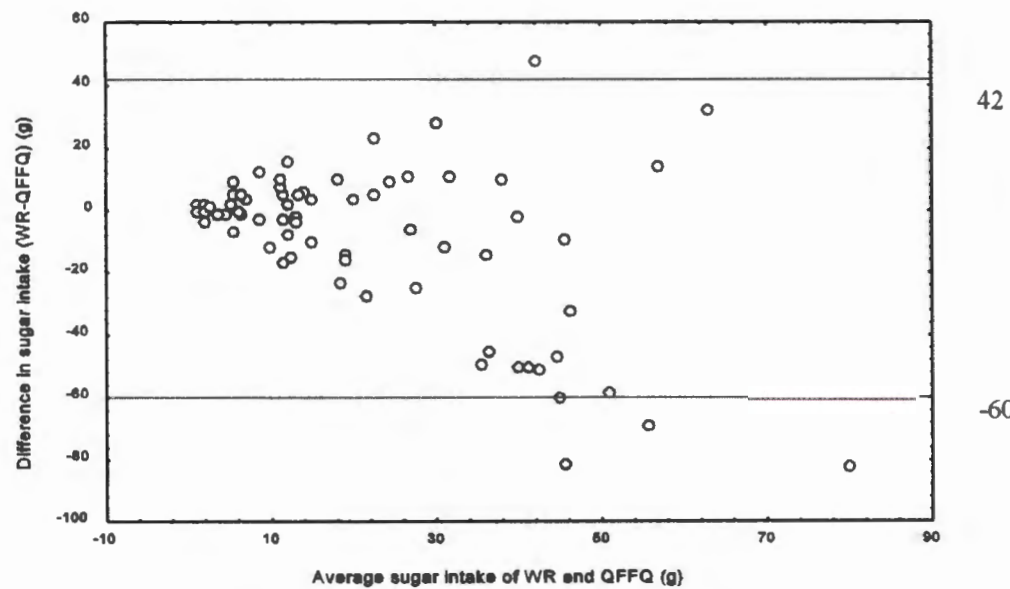


Figure 7.11: Bland-Altman plot for sugar.

According to the Bland-Altman analysis, there was good agreement between the QFFQ and the seven-day weighed record for all food groups, the lowest level of agreement being for legumes at 89%. Only the fruit, rice and sugar groups showed significant proportional bias. The Bland-Altman plots for maize meal and sugar are presented to illustrate contrasting patterns of agreement and proportional bias. The level of agreement for maize meal is the second lowest of the food groups (91%). This is in contrast to the good validity results obtained for the Spearman rank correlation coefficient (0,56; $P<0,001$) and the paired t-test ($P>0,05$). However, as can be seen from the even spread of observations on the plot, there is virtually no proportional bias. On the other hand, sugar shows slightly better agreement (95%) but significant proportional bias.

- (d) Agreement between quintiles of the distributions of food groups for the seven-day weighed record and the quantitative food frequency questionnaire

The final analysis to determine the validity of the QFFQ was to compare the position of subjects within the distributions of the food groups for the QFFQ and the seven-day weighed record. As can be seen from Table 7.14 below, for all food groups for the sample as a whole, 67% or more subjects could be classified into the same or adjacent quintiles on both dietary intake assessment methods.

Table 7.14 Classification of subjects into the same and adjacent quintiles of the distribution for the QFFQ and the seven-day weighed food record (N=74)

	Entire sample (N=74)				Males (N=15)				Females (N=59)			
Food group	Cumulative %				Cumulative %				Cumulative %			
	*S	±1	±2	±3	*S	±1	±2	±3	*S	±1	±2	±3
Milk	40	76	95	98	33	67	93	100	42	78	94	96
Meat	31	79	89	98	27	73	80	93	33	80	91	98
Fish	44	79	86	97	27	73	80	97	49	82	89	96
Legumes	50	67	84	97	73	87	100	100	44	63	81	97
Eggs	47	71	75	76	33	67	67	67	51	73	77	81
Fruit	44	81	96	99	40	87	100	100	45	80	76	80
Vegetable	40	87	100	100	53	93	100	100	36	85	90	90
Maize meal	63	83	93	100	53	80	87	100	65	84	94	99

	Entire sample (N=74)				Males (N=15)				Females (N=59)			
Food group	Cumulative %				Cumulative %				Cumulative %			
	*S	±1	±2	±3	*S	±1	±2	±3	*S	±1	±2	±3
Rice	59	86	92	96	53	67	80	60	60	91	95	99
Samp	61	84	91	97	80	93	100	100	56	82	89	96
Other cereals	79	94	95	95	87	93	93	93	76	95	97	97
Bread	36	76	93	100	20	53	93	100	40	82	93	100
Fat	53	84	94	98	60	93	93	93	51	82	95	100
Sugar	53	81	94	98	60	93	93	93	51	78	94	100

S=classified into the same quintile; ±1=adjacent quintiles;±2= two quintiles difference; ±3= 3 quintiles difference of the distributions of the seven-day weighed record and the QFFQ

Once again it is encouraging to note the relatively high agreement for maize meal, with 63% of subjects being classified into the same quintile. The males achieved the highest levels of agreement with 93% of subjects being classified into the same and adjacent quintiles for the vegetable, samp, ‘other’ cereal, fat and sugar groups. The ‘other’ cereal group showed the highest level of agreement for both the entire sample (94%) and the females (95%). Also of interest is that the agreement for fat as a food group (84%) is higher than for fat as a nutrient (74%).

7.3.2 24-Hour urinary nitrogen

7.3.2.1 Sample description

Of the 104, 24-hour urine samples collected, 16 (15%) samples were excluded because no PABA was found on analysis. Thus, the sample comprised 88 subjects recruited from all strata and age groups. Of these 88 samples, 32 (36,4%) contained 85% (204 mg) or more of the administered 240 mg of PABA and were taken as complete 24-hour urine collections. Table 7.15 shows the distribution of the sample according to age, gender, stratum of urbanisation and BMI for the complete and incomplete urine collections.

Table 7.15: Distribution of the sample of 24-hour urine collections

	Complete*		Incomplete**		Total	
	N	%	N	%	N	%
Gender: Males	13	40,6	12	21,4	25	28,4
Females	19	59,4	44	78,6	63	71,6
Age group (years) 15 - 24,9	3	9,4	6	10,7	9	10,2
25 - 34,9	11	34,4	16	28,5	27	30,7
35 - 44,9	5	15,6	18	32,1	23	26,1
45 - 54,9	11	34,4	7	12,5	18	20,5
55 - 64,9	2	6,2	9	16,1	11	12,5
Stratum: Rural	3	9,4	17	30,4	20	22,7
Farm	5	15,6	2	3,6	7	8,0
Informal settlement	6	18,8	11	19,6	17	19,3
Middle-class urban	11	34,4	11	37,5	22	25,0
Upper-class urban	7	21,9	5	8,9	12	13,6
¶BMI (kg/m ²) < 21	3	9,4	13	23,2	16	18,2
21 - 26,9	15	46,9	20	35,7	35	39,8
>= 27	14	43,8	23	41,1	37	42,0

¶BMI=body mass index; *Complete: urine specimens containing at least 204 mg PABA; **Incomplete: urine specimens containing less than 204 mg PABA

There were no significant differences in the percentages of complete urine collections between genders or BMI ($P>0,05$). The percentage of complete collections in the age group of 45 to 54,9 years was significantly higher than that of the 35 to 44,9-year age group ($P<0,05$) and that of the 55 to 65-year age group ($P<0,05$), but did not differ significantly from the two younger age groups ($P>0,05$). The most noticeable differences in the percentages of complete collections appear among the strata of urbanisation. The percentage of complete collections obtained from the rural subjects is significantly lower than the percentages from the farm, middle-class and upper class strata ($P<0,05$) although not to the informal settlement stratum ($P>0,05$). This very low percentage could be ascribed to a number of factors, relating both to the subjects and to the methodology. The logistics of collecting and keeping a urine sample over 24-hours could have been more difficult for the rural subjects than for subjects in other areas. Toilets in the area were outside pit-type and usually shared by more than one household, making collection difficult.

From the methodological point of view, the samples had to be measured in a 'makeshift' laboratory, which could have affected the accuracy of the measurement of the volumes, for practical reasons the urine could not be measured and frozen soon after collection (all research assistants were busy with dietary intake interviews and other measurements) and the environmental temperatures were higher than 30°C. The effects of temperature and standing on PABA concentrations are not known. It is notable that the most complete collections were in the middle and upper class strata, where the practicality of urine collection would be easier. Another factor which could affect the collection of complete specimens could be the ability of the subjects to understand and follow the instructions. However, the farm workers, most of whom were illiterate, had a high percentage of complete collections.

Table 7.16 compares the analyses of the complete and incomplete specimens.

Table 7.16: Analyses of complete and incomplete 24-hour urine collections (N=88).

	Complete (N=32)		Incomplete (N=56)		††95% CI
	Mean	†SD	Mean	†SD	
Age (years)	38,8	11,2	38,7	12,5	-5,2-5,4
Body mass index (kg/m ²)	26,9	6,0	26,5	6,2	-2,3-3,1
Volume (ml.)	1783	775	1499	665	-27,3-595
§PABA (%)	91,9	6,8	57,2	18,1	28,1-41,3***
Nitrogen (g)	9,0	2,6	6,5	4,3	0,836-4,16**
¶Protein (g)	70,0	28,2	53,7	17,7	6,6-26,0**
‡Protein intake (g)	77,9	27,0	68,6	23,7	-1,69-20,3
¶¶UN:NI	0,8	0,5	0,7	0,4	-0,09-0,29

†SD: standard deviation; ††95%CI: 95% confidence interval; ¶Protein= 6,25(Nitrogen+0,031x body weight); ‡Protein intake (g): protein intake derived from QFFQ; §PABA: *para*-amino benzoic acid; ¶¶UN:NI : Ratio of urinary nitrogen to dietary nitrogen intake; Level of significance: ** P<0,01; *** P<0,001

There were no significant differences between the mean age and BMI of the subjects whose urine specimens were complete and of those whose specimens were incomplete (P>0,05). Although the mean volumes did not differ significantly, as could be expected, the percentage of PABA, the nitrogen content and the equivalent protein intake were significantly different (P<0,001). As done by O'Donnell *et al.* (1991), both incomplete and complete specimens were included in the further analyses.

7.3.2.2 Comparison of protein calculated from urinary nitrogen and from QFFQ

There was no significant correlation between the protein intake estimated from the urinary nitrogen and the reported intake from the QFFQ for either the entire sample ($r=-0,07$; $P>0,05$) or for the complete specimens only ($r=0,01$; $P>0,05$). For the entire sample, the mean calculated urinary protein was significantly lower than the mean reported intake ($P<0,001$) but this difference was not significant when the results of the complete specimens were analysed ($P>0,05$). Figures 7.12 and 7.13 show the Bland-Altman plots for urinary protein and protein intake for the 88 specimens and the 32 complete specimens respectively.

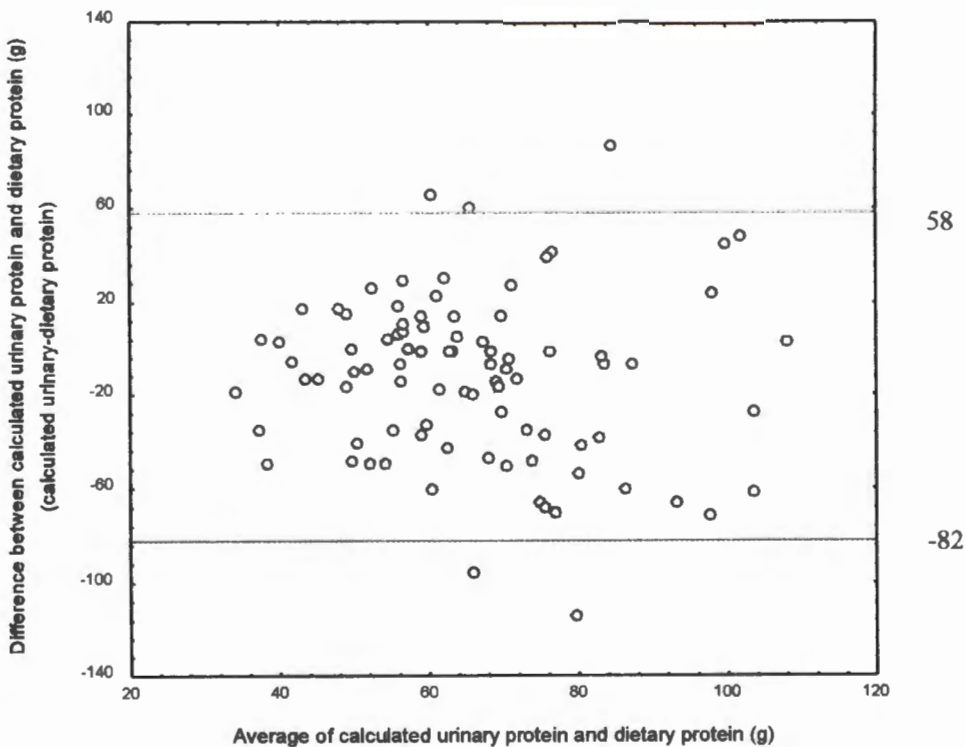


Figure 7.12: Bland-Altman plot for calculated urinary protein and dietary protein for all collections (N=88)

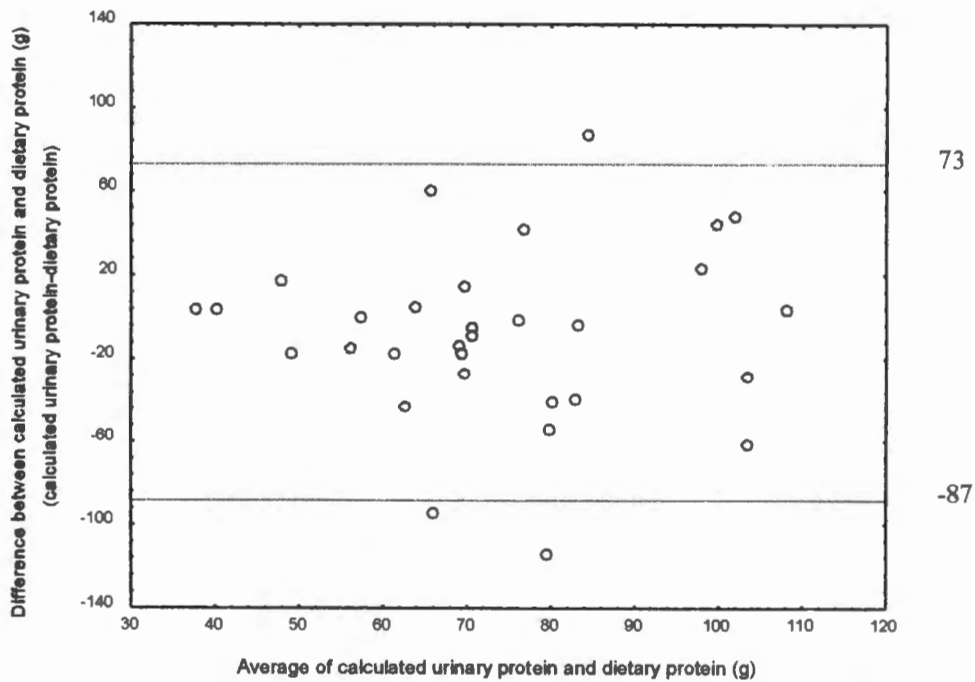


Figure 7.13: Bland-Altman plot for calculated urinary protein and dietary protein for complete collections (N=32)

The above plots appear similar. Differences are smaller at low intakes. As the mean increases, so do the differences but there is no proportional bias ($r=-0,1$ for $N=88$ and $r=0,01$ for $N=32$). The number of subjects where the calculated urinary protein is greater than the reported protein is approximately the same as the number of cases where the reported intake exceeds the urinary excretion. The ratios of agreement (sd/sm) for both the entire sample and the complete cases were large and very similar (2,2 and 2,3 respectively) indicating that agreement between the two measures was poor, even when the 24-hour urine collection was complete.

The final analysis, that is, the comparison of the distributions into quintiles confirms the poor agreement between dietary intake and urinary nitrogen (Table 7.17). Only 65% of subjects could be classified into the same or adjacent quintiles in both distributions. The percentage was slightly higher for the complete specimens, but the difference was not significant ($P>0,05$).

Table 7.17: Cumulative percentage of subjects classified into quintiles of urinary protein and dietary protein

	Cumulative %			
	*S	§ ±1	§ ±2	§ ±3
All specimens (N=88)	30	65	80	90
Complete specimens (N=32)	34	69	82	91

*S: within the same quintile; §±1,2,3: within one, two or three quintiles

7.3.2.3 Comparison of protein intake calculated from urinary nitrogen and from the seven-day weighed records

Of the 74 subjects who completed seven-day weighed records, 46 gave a 24-hour urine sample. To test the validity of the weighed records, the reported protein intake was compared with that calculated from the urine specimens. Since the sample number was small and since, from the above analyses, it does not appear that the results obtained from complete collections differ from the incomplete collections, the results are presented for all 46 subjects. Table 7.18 summarises the results of the statistical analyses.

Table 7.18: Comparison of protein intake calculated from urinary nitrogen and reported protein intake from seven-day weighed records (N=46)

Analysis	Result	‡95% CI
Number complete specimens	17 (37%)	
Spearman R	0,03	-0,263-0,0318
†Urinary protein-dietary protein	-14,5; % difference=21	-24,0 - -4,9**
Bland-Altman plot	Spearman R=0,24 sd/sm=1,9	-0,054-0,490
Quintile distribution	¶S=33%; §±1=74%; ±2=91%; ±3=99%	

†Paired t-test; ¶S: within the same quintile; §±1,2,3: within one, two or three quintiles;
‡95% CI: 95% confidence interval; Level of significance: ** P<0,01

The results of the urinary analyses and the seven-day weighed record are similar to those obtained for protein with the QFFQ. Better results might have been expected as both the weighed record and the urine specimen were collected at the same time. Thus, the urine specimen should reflect the protein intake more accurately. However, this does not appear to be the case. The

Spearman Rank correlation coefficient, paired t-test and Bland-Altman plot all show poor results similar to those obtained with the QFFQ. The results of the quintile distributions are slightly better than those obtained for the QFFQ, with 74% of the subjects falling within the same or adjacent quintiles and only 1% being grossly misclassified.

7.3.3 Identification of underreporters

Underreporters are identified by a ratio of energy intake (EI) to basal metabolic rate (BMR) of less than 1,2 or a ratio of urinary nitrogen to nitrogen intake of greater than one (Bingham, 1991). These ratios were calculated, where applicable, for the sample who collected 24-hour urine samples and completed the QFFQ (N=88; 7.3.2.1), the subjects who collected 24-hour urine samples and kept weighed records (N=46; 7.3.2.3), the subjects who kept weighed records (N=74; see 7.3.1.1), the reproducibility sample for both administrations of the QFFQ (N=144; 6.3.1) and entire dietary intake sample (N=890; 8.2.1). The results are presented in Table 7.19.

Table 7.19: Identification of underreporters

Sample		N	*UN:NI Mean ¶SD		**EI:BMR Mean ¶SD		%Underreporters UN:NI EI:BMR	
24-hour urine & QFFQ	Total	88	0,73	0,50	1,47	0,51	19	36
	Males	25	0,64	0,42	1,53	0,49	12	32
	Females	63	0,74	0,49	1,46	0,52	22	38
24-hour urine & weighed records	Seven-day weighed record compared to BMR and urinary nitrogen excretion							
	Total	46	0,68	0,38	1,43	0,38	10	28
	Males	10	0,53	0,25	1,47	0,39	0	30
	Females	36	0,72	0,41	1,42	0,38	14	27
	Quantitative food frequency questionnaire compared to BMR and urinary nitrogen excretion							
	Total	46	0,78	0,51	1,40	0,5	30,0	43
	Males	10	0,75	0,53	1,16	0,37	10,0	53
	Females	36	0,80	0,51	1,47	0,53	26,0	41
Weighed records	Seven-day weighed record compared to BMR							
	Total	74			1,47	0,43		28
	Males	15			1,62	0,45		20
	Females	59			1,42	0,41		30
	Quantitative food frequency questionnaire compared to BMR							
	Total	74			1,42	0,43		43
	Males	15			1,32	0,44		41
	Females	59			1,46	0,53		53

Reproducibility †QFFQ1	Total	144			1,35	0,49		39
	Males	45			1,36	0,50		42
	Females	99			1,35	0,49		37
Reproducibility ‡QFFQ2	Total	144			1,43	0,55		39
	Males	45			1,42	0,55		37
	Females	99			1,43	0,55		40
Dietary intake	Total	889			1,37	0,47		40
	Males	338			1,37	0,46		40
	Females	552			1,37	0,48		41

*UN:NI= Urinary nitrogen excretion (g) / dietary nitrogen intake(g)

**EI:BMR=Energy intake (kJ)/ estimated basal metabolic rate (kJ) (see Table 5.2 for formulae)

¶SD=Standard deviation; †QFFQ1: first administration of quantitative food frequency questionnaire; ‡QFFQ2: repeat administration of quantitative food frequency questionnaire.

The range of means for the UN:NI ratio (0,53 to 0,8) obtained for the various samples were within the limits for valid reporting. With the exception of the mean EI:BMR ratio calculated for the QFFQ for the 10 males in the 24-hour urine and weighed record sample, the mean EI:BMR ratios (1,32 to 1,47) were greater than 1,2. However, the coefficients of variation (CV) for the UN:NI were 69% and 56% compared to 34% and 26% for the EI:BMR of the 24-hour urine and QFFQ and the 24-hour urine and weighed record samples respectively. The high CV for the UN:NI reflects the high variability and consequently the unreliability of the results. For the weighed record and 24-hour urine sample (N=46) the mean ratio of urinary nitrogen to dietary nitrogen was significantly higher for the QFFQ than for the seven-day weighed record ($P<0,05$) for the total sample. The differences between the mean EI:BMR ratios between the weighed records and the QFFQ were not significant for either the total weighed record sample (N=74) or the weighed record and 24-hour urine sample ($P>0,05$).

Figures 7.14 and 7.15 show the comparison of the validation results of the seven-day weighed records against BMR and 24-hour urinary nitrogen excretion and of the QFFQ against BMR and 24-hour urinary nitrogen excretion respectively.

The procedure described by Black *et al.* (1995) was used to compare the use of urinary nitrogen and energy expenditure for identifying underreporters. Figures 7.14 and 7.15 show the relationships between the EI:BMR ratio and the UN:NI ratio for the seven-day weighed record and the QFFQ respectively.

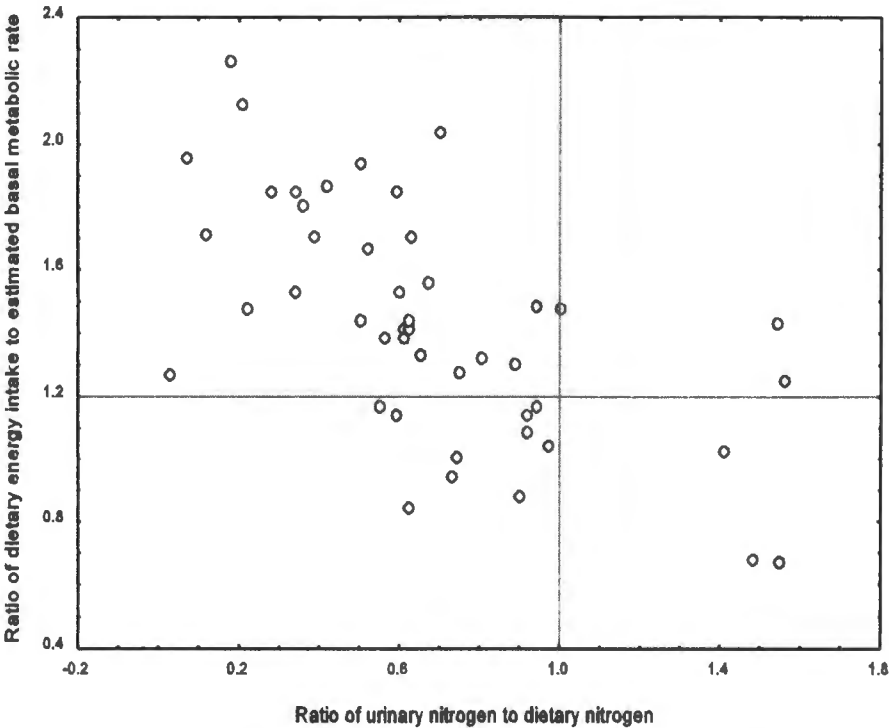


Figure 7.14: Comparison of validation of seven-day weighed records against BMR and 24-hour urinary N excretion, individual data (N=46)

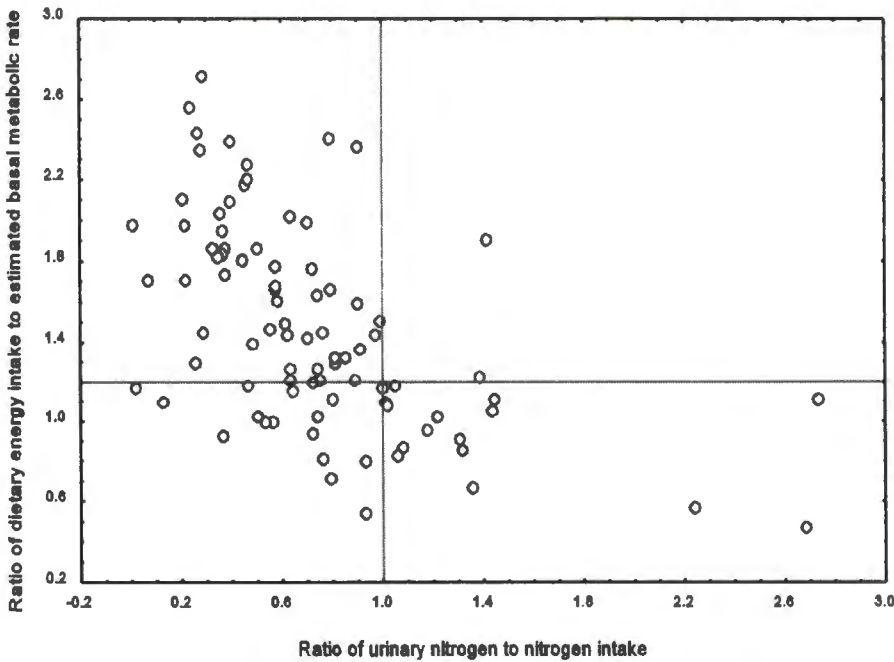


Figure 7.15: Comparison of validation of QFFQ against BMR and 24-hour urinary N excretion, individual data (N=88)

For the seven-day weighed record (Figure 7.14), three subjects (lower right cell) were identified as underreporters using both methods; two subjects as underreporters according to the UN:NI (upper right cell) and 10 as underreporters according to EI:BMR only (lower left cell). For the QFFQ (Figure 7.15), 13 subjects could clearly be classified as underreporters (right lower cell), while the status of 18 subjects was not clear, 16 appearing to give invalid reports according to EI:BMR only and two according to UN:NI only. However, it is encouraging to note that 67% and 65% of subjects of the weighed record sample and the QFFQ sample respectively had given valid reports, with both methods of validation.

Significantly more underreporters were identified using the energy ratio than with the UN:NI ($P<0,05$) on both the 24-hour urine sample and the weighed record sample. Considering the poor performance of urinary nitrogen in the forgoing analyses, it could be assumed that the energy intake: BMR ratio provides the more accurate estimation. With regard to gender, there were no significant differences in the proportions of male and female underreporters in any of the samples ($P>0,05$). Importantly, the number of underreporters was almost exactly the same for both administrations of the QFFQ. Underreporting appeared to be less marked with the seven-day weighed record.

An important consideration for the dietary intake study was whether any subgroup, i.e. among strata of urbanisation, age group and BMI was more likely to underreport than another. As can be seen from Table 7.20, fewer subjects in the youngest age group ($P<0,05$) and with BMI lower than 21 kg/m^2 ($P<0,001$) were underreporters than in the other groups. There were no significant differences among the proportions of underreporters for the strata of urbanisation ($P>0,05$).

Table 7.20: Percentage of underreporters according to strata of urbanisation, age group and body mass index

Variable	Category	N	% Underreporters
Stratum of urbanisation	Rural	231	37,7
	Farm	128	43,0
	Informal settlement	121	43,8
	Middle class urban	213	39,9

Age group (years)	15 - 24,9	218	32,1*
	25 - 34,9	221	37,6
	35 - 44,9	185	46,5
	45 - 54,9	163	44,2
	55 - 64,9	103	46,6
Body mass index (kg/m ²)	< 21	295	30,2**
	21 - 26,9	335	43,3
	>=27	260	48,1

*Significantly different from other age groups $P<0,05$; ** Significantly different from other BMI groups, $P<0,01$.

7.3.4 Structural equation models

The results of the statistical analyses reported thus far have used the seven-day weighed record as the reference method against which the QFFQ was tested. However, these methods have not taken account of the fact that the reference method itself is subject to errors, both within and between subjects (see Section 7.2.4). Although traditionally weighed records have been taken as representing the 'true' intake in validation studies, it is in fact impossible to physically measure the 'true' dietary intake of individuals. All measures of dietary intake, no matter how closely controlled are subject to variation and error, and even more so when conducted under field conditions with subjects to whom the whole concept of research is unfamiliar, as was done in the present study. In consequence, some of the results already presented appear almost contradictory.

For example, for total protein, the Spearman rank correlation coefficient is significant (0,3) indicating that there is some connection between the QFFQ and the seven-day weighed record. However, when the mean protein intakes were compared there was a significant difference of 13,6% between them, suggesting that the two methods were not giving the same results. To make the results even more confusing, there was no correlation between the protein intake and that calculated from the urinary nitrogen for either the QFFQ or the seven day weighed record. By contrast, the Spearman rank correlation coefficient for fibre was not significant (0,1) but neither was the difference between means.

In an attempt to bring the results of the various aspects of the validation study into perspective

and to compare the QFFQ to the true intake, the methods of Kaaks *et al.* (1994b) and Beaton (1991) were applied with certain modifications as described in Section 7.2.4 to the data obtained in the present validation study. The equation $Q = \alpha_Q + \beta_Q T + \varepsilon_Q$ (equation 1) gives the relation between the nutrient intake derived from the QFFQ (Q) and the unknown true intake (T). The coefficient α_Q represents the constant bias, that is, the difference between the QFFQ intake and the true intake is the same across all levels of individual intakes in the sample. The coefficient β_Q reflects the proportional bias, that is, the intake derived from the QFFQ is linearly dependent on the true intake. For example, as the intake increases so does the difference between measured and true intake. If the QFFQ was a perfect reflection of the true intake, there should be no constant bias ($\alpha=0$) and no proportional bias ($\beta=1$) (Kaaks & Riboli, 1997). In addition, the validity coefficient $\rho(Q,T)$, that is, the correlation of the intake derived from the QFFQ and the true intake (equation 4; 7.3.2.1) should be high. Thus, the desired results are an α_Q approaching zero (95% Confidence interval including 0), β_Q close to one (95% confidence interval including 1) and a strong validity coefficient. Tables 7.21 and 7.22 show the β_Q and α_Q calculated by the various methods from the simplest based only on mean intakes (Kaaks method 1), the modification of Kaaks' method using each day of the seven-day weighed record as a separate parameter and the inclusion of the biomarker. Table 7.23 shows the $\rho(Q,T)$ obtained from the various methods.

Table 7.21: Comparison of proportional bias (β_Q) calculated by the different methods

Parameter ¶ Number of days	*Kaaks 1		**Kaaks 2 modified		#Biological marker	
	5	7	5	7	5	7
Energy 95% §CI	0,3238 0,1019- 0,5457	0,3573 0,1160- 0,5986	0,4308 0,1382- 0,8862	0,5122 0,0992- 0,7624	0,5968 -0,8743- 2,0679	0,5965 -0,9272- 2,1202
Protein 95% CI	0,2424 0,0337- 0,4519	0,3238 0,1019- 0,5457	0,3679 0,0847- 0,6511	0,5792 0,9673- 0,1785	2,477 -20,79 - 26,29	3,4329 -32,33- 39,20
Total fat 95% CI	0,3071 0,0793- 0,5349	0,1157 0,0281 0,2033	0,7940 0,230- 1,3584	0,4687 0,0332- 0,9042		
Calcium 95% CI	0,2406 0,0014- 0,4797	0,3095 0,0631- 0,5587	0,2007 0,0053- 0,3961	0,2907 0,0302- 0,5510		
Iron 95% CI	0,2160 -0,015- 0,4471	0,2234 -0,250- 0,4733	0,2043 -0,0879- 0,4965	0,3448 0,0183- 0,6713		

Vitamin A 95% CI	0,2904 0,1367- 0,4439	0,2867 0,1162- 0,4568	0,4622 0,1613- 0,7631	0,4274 0,1645- 0,6902		
Vitamin C 95% CI	0,5074 0,3074- 0,7101	0,5522 3,3376- 0,7668	0,6809 0,2893- 1,0725	0,8892 0,3747- 1,4037		

§CI=Confidence interval; *Method 1,** Method 2(b),# Method 3 of Kaaks *et al.*, (1994b) modified as described in Section 7.2.4;¶ Number days : coefficients obtained from weighed records for five week days (excluding weekends) and the complete seven days

Table 7.22: Comparison of constant bias (α_Q) calculated by the different methods

Parameter ¶ Number of days	*Kaaks 1		**Kaaks 2 modified		#Biological marker	
	5	7	5	7	5	7
Energy 95% §CI	6,2330 4,2515- 8,2139	5,7836 3,6053- 7,9619	5,1226 2,1313- 8,1136	4,4014 1,0377- 7,7652	3,6156 -9,7844- 17,0156	3,6171 -10,2773- 17,5115
Protein 95% CI	3,1348 2,2468- 4,0227	2,777 1,8254- 3,7290	2,5968 1,4104- 3,7816	1,7502 0,0832- 3,1417	-7,514 -107,02- 91,992	18,872 -133,69- 171,43
Total fat 95% CI	2,8830 1,9322- 3,8338	3,2390 2,5350- 3,9430	0,9247 -1,3861- 3,2355	2,2248 0,4211- 4,0286		
Calcium 95% CI	4,5987 3,1130- 6,0840	4,172 2,642- 5,702	4,8687 3,6753- 6,0624	4,352 2,766- 5,938		
Iron 95% CI	1,7197 1,1881- 2,2515	1,6815 1,102- 2,260	1,757 1,1057- 2,4083	1,4408 0,7208- 2,1606		
Vitamin A 95% CI	4,744 3,764- 5,724	4,692 3,575- 5,807	3,8848 2,1454- 5,6244	4,064 2,5215- 5,6068		
Vitamin C 95% CI	2,0632 1,2678- 2,8586	1,8039 0,948- 2,660	1,6042 0,2220- 2,986	0,8526 -0,959- 2,6642		

§CI=Confidence interval; *Method 1; **Method 2(b); #Method 3 of Kaaks *et al.*, (1994b) modified as described in Section 7.2.4;¶ Number days : coefficients obtained from weighed records for five week days (excluding weekends) and the complete seven days.

With regard to proportional bias, the modification of Method 2 of Kaaks *et al.* (1994b) appears to give values closer to one than Method I for all nutrients except calcium and iron. The only nutrients showing no significant proportional bias with Method 2 are total fat (5 days) and vitamin C (5 and 7 days). The energy calculations show the effect of including the error terms and the benefit of a biomarker. β_Q calculated with Method I is the lowest, then increases to 0,5

on the second method, but the proportional bias is still significant. However, when the biomarker, BMR, is included as the third independent parameter, β_Q increased to 0,6 and, importantly, the proportional bias is no longer significant. The β_Q for protein shows a similar improvement between methods one and two. However, the attempt to include urinary protein as the third independent marker failed to produce a meaningful result. β_Q increased to 3, and although the 95 confidence intervals include 1, they are so wide as to be meaningless. This could be due to the very wide variability of the urinary nitrogen and the fact that the negative correlation between urinary protein and the protein intake obtained from the QFFQ (-0,008) did not fit the model.

When looking at the constant bias, α_Q , total fat (5 days) and vitamin C (7 days) are the only nutrients for which the 95% confidence intervals include zero. Again method 2 gives results closer to zero than method 1. Direct comparisons of the degree of constant bias between nutrients is not possible because of the differences in the scales of measurement and variation of the nutrient. As for β_Q , the value α_Q for energy intake improved when BMR was used as the biomarker, but the model failed with the use of urinary protein.

Table 7.23: Comparison of validity coefficients ($\rho(Q,T)$) calculated by the different methods

Parameter ¶Number of days	*Kaaks 1		**Kaaks 2 modified		§Beaton		#Biological marker	
	5	7	5	7	5	7	5	7
Energy	0,3121	0,3278	0,3396	0,3799	0,328	0,355	0,4344	0,4206
Protein	0,2574	0,3175	0,3618	0,4466	0,301	0,349	0,444	-
Total fat	0,2954	0,2916	0,205	0,312	0,379	0,331		
Calcium	0,2460	0,2820	0,2909	0,3005	0,252	0,293		
Iron	0,2096	0,2050	0,2058	0,3095	0,247	0,256		
Vitamin A	0,3970	0,3670	0,5853	0,5622	0,482	0,441		
Vitamin C	0,4980	0,5164	0,6604	0,6749	0,618	0,658		

*Method 1; **Method 2(b); # Method 3 of Kaaks *et al.*, (1994b) modified as described in Section 7.2.4 ; §Method of Beaton (1991) with modification from Dunn (1989) (Section 7.2.5)

¶ Number days : coefficients obtained from weighed records for five week days (excluding weekends) and the complete seven days.

Generally the highest validation coefficients were obtained with Method 2 using the seven-day weighed record and were also higher than Beaton's method. Although total fat had no significant

constant or proportional bias, its validation coefficient is relatively low. On the other hand, vitamin C appears to be the closest to the true intake with no significant constant or proportional bias and a high validation coefficient. Also, the inclusion of BMR as biomarker improved the validation coefficient for energy. Although the calculation of $\rho(Q,T)$ including urinary protein as a biomarker for the five-day weighed record produced a slight improvement in the correlation, when applied to the seven-day weighed record, the model failed due to a negative value for σ^2 (-0,005).

In comparison to the Spearman rank correlation coefficients for the seven-day weighed record and QFFQ (Table 7.4), method 1 gives very similar values (as would be expected as error terms are not included in either method) but method 2 give higher values. Again, the validation coefficients are higher for the seven-day weighed record than for the five days. The results of Beaton's method seem to fall somewhat between method 1 and method 2.

A small subsample (N=23) of the seven-day weighed record subjects had also completed the second administration of the QFFQ. Method 3 was applied to the energy intake results of these subjects to investigate the relationship between the results of the two QFFQ and the seven-day weighed record. This analysis gave a relatively small proportional bias ($\beta_Q = 1,7548$, 95% CI: 0,166 to 3,344) but a very large and apparently inaccurate α_Q (-6,89, 95% CI: -7,068 to 21,95). The validity coefficient was higher (0,682) than that obtained from any of the other analyses.

The methods described by Kaaks *et al.* (1994b) have been applied only to nutrient intake. However, in the present study, the accuracy of the recording of intake in terms of food is also of interest. To see if the methods of Kaaks *et al.* (1994b) could be applied to food, rather than nutrient, intake, maize meal intake was analysed using adaptations of methods 1 and 2. Table 7.24 gives the results obtained for β_Q , α_Q and $\rho(Q,T)$ when method 1 was applied to the intakes obtained from the QFFQ and seven-day weighed record, and the two administrations of the QFFQ, and Method 3 to the two replicates of the QFFQ and the seven day weighed record.

Table 7.24: Proportional bias (β_Q), constant bias (α_Q) and validity coefficients ($\rho(Q,T)$) obtained for maize meal intake

	*QFFQ1 & **WR (N=74)	*QFFQ1 & ***QFFQ2 (N=144)	*QFFQ1, ***QFFQ2 & **WR (N=23)
$\dagger \beta_Q$ $\P 95\% \text{CI}$	0,5300 0,0112-1,0488	0,5025 0,3267-0,6783	1,2157 0,3727-1,9260
$\ddagger \alpha_Q$ $\P 95\% \text{CI}$	7,1522 2,874-11,44	2,312 0,3267-4,297	-0,0869 -2,57 - 0,834
$\ddagger \rho(Q,T)$	0,3656	0,436	0,797

*QFFQ1: First administration of quantitative food frequency questionnaire; ** WR: seven-day weighed record; ***QFFQ2: Second administration of quantitative food frequency questionnaire; $\P 95\% \text{CI}$: 95% Confidence interval $\dagger \beta_Q$: Proportional bias; $\ddagger \alpha_Q$: constant bias; $\ddagger \rho(Q,T)$: validity coefficient.

The validity coefficient calculated using Method 1 of Kaaks *et al.* (1994b) was 0,3656 which was somewhat lower than the Spearman rank correlation coefficient (0,564). However, the coefficient calculated from the intakes of the two administrations of the QFFQ was very close to the Spearman rank correlation coefficient obtained for reproducibility (0,452 Table 6.12). The best results were obtained when all three measures were combined, giving high agreement (0,8) with neither proportional nor constant bias. Since the number of subjects used for the last calculation was small (23), these values need to be interpreted cautiously. Nevertheless, $\rho(Q,T)$ appears to be in the range of moderate to good agreement (0,4 to 0,8), slight proportional bias (0,5 to 1,2), but possible considerable constant bias (-0,1 to 7).

Figure 7.16 shows the relationships between the QFFQ, the seven day weighed record and the true intake as calculated by the method of Beaton (1991) (using seven-day weighed records).

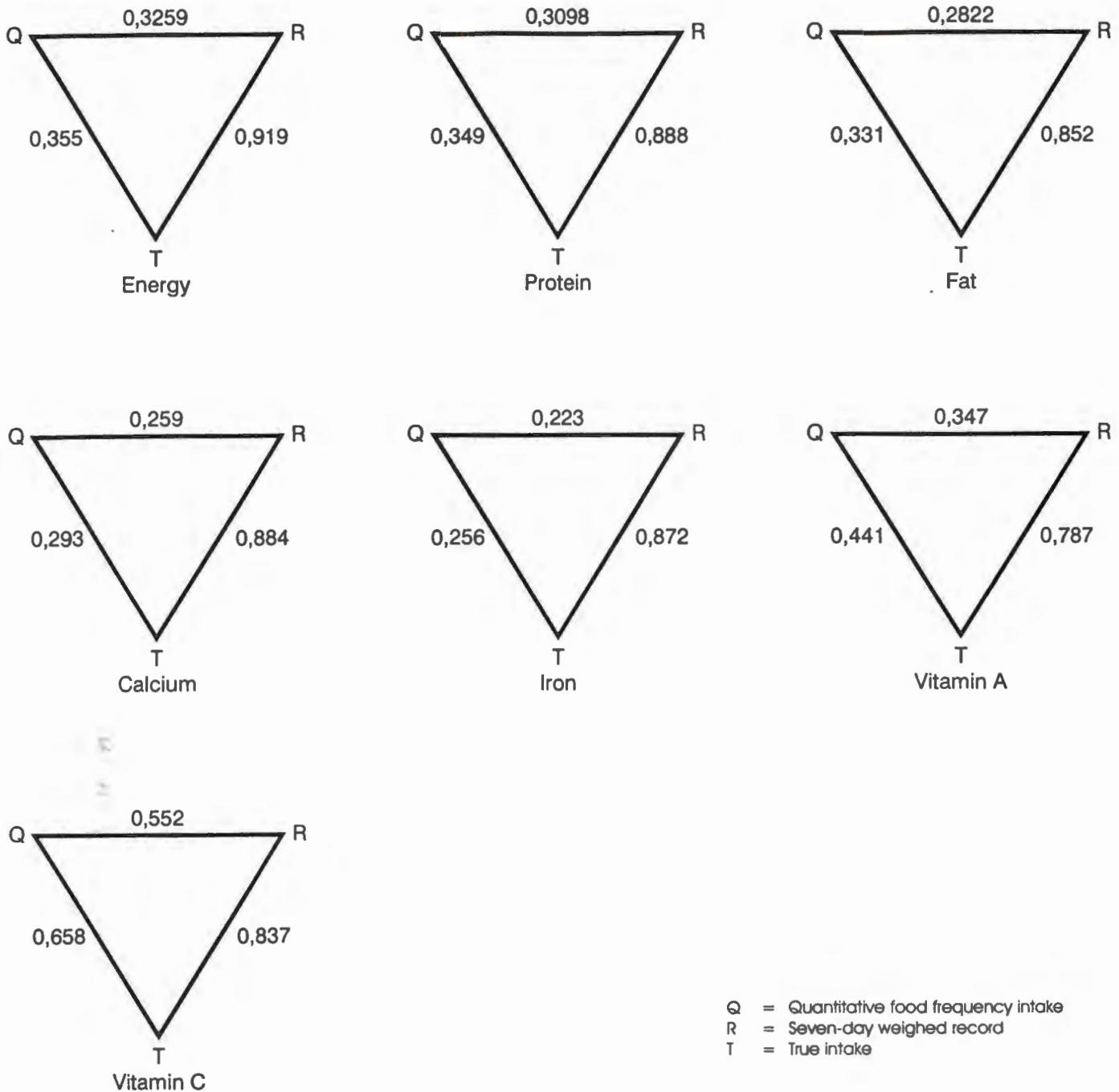


Figure 7.16: Relationship between nutrient intakes from the quantitative food frequency questionnaire, seven-day weighed record and true intake

From the various coefficients of correlation and validity presented in this chapter, it seems difficult to come to a clear conclusion regarding the validity of the QFFQ, and thus also to apply these results to interpretation of the dietary intake study. One way of summarising the results of the validation study, as suggested by Kaaks & Riboli (1997) is to consider the coefficients as ranges, rather than single values. Kaaks & Riboli (1997) suggest that the observed sample

correlation between biomarker and QFFQ be taken as a lower limit for $\rho(Q,T)$ and that the estimated $\rho(Q,T)$ obtained by using the structural equation models and biomarker be taken as the upper limit. Since the correlation of urinary and dietary protein in the present study was negligible, the values of $\rho(Q,T)$ calculated without using error terms and seven-days (method I) and those obtained from using SEM with the seven-day weighed record will be taken as the lower and upper limits respectively. In the case of energy, the upper limit will be the triangular calculation with BMR as the biomarker. Table 7.25 summarises these ranges of agreement. The Spearman rank correlation coefficients between the mean reported intakes derived from the seven-day weighed records and the reported intake from the QFFQ are shown for comparison.

Table 7.25: Range of validity coefficients

Nutrient	Lower limit $\rho(Q,T)$	Upper limit $\rho(Q,T)$	Spearman R
Energy	0,3278	0,4206	0,311
Protein	0,3175	0,4466	0,295
Total fat	0,2916	0,312	0,250
Calcium	0,2826	0,3005	0,237
Iron	0,2050	0,3095	0,198
Vitamin A	0,3670	0,5622	0,216
Vitamin C	0,5164	0,6749	0,597

For all nutrients, except Vitamin C, the Spearman rank correlation coefficient is lower than the lower limit of $\rho(Q,T)$. Also, with the exception of fat, $\rho(Q,T)$ calculated using the method of Beaton, falls within the limits. Using the guidelines for strength of agreement quoted by Dunn (1989), one nutrient (vitamin A) clearly has moderate agreement, two nutrients (energy and protein) range from fair to moderate agreement, one nutrient (vitamin C) had moderate to substantial agreement and three nutrients (fat, calcium and iron) have fair agreement. Overall agreement ranges from 0,2 (iron) to 0,7 (vitamin C) with a mean upper limit of agreement of 0,41 (SD=0,14), in other words, moderate agreement.

The advantage of using the SEM is that it not only gives an objective measure of validity but also,

by the calculation of α_Q and β_Q , provides a means of adjusting the reported nutrient intakes according to the constant and proportional bias, as well as identifying nutrients for which no adjustment is necessary. From Table 7.21, energy (using the biomarker method) and vitamin C (Kaaks method 2) appear not to have significant proportional bias and from Table 7.22 these also appear not to have significant constant bias. Thus, the reported mean intakes of energy and vitamin C may be accepted as valid without any adjustment for bias. In contrast, the other nutrients for which α_Q and β_Q were calculated appear to have proportional and constant bias of varying degrees. Adjustment of the reported intakes according to this bias is by the following equation derived from equation (1) (Kaaks *et al.*, 1994b): $Q' = (Q - \alpha_Q) / \beta_Q$.

To illustrate the application of the above equation, examples of reported intakes and their adjusted values using the results of method 2 are shown in Table 7.26

Table 7.26: Adjusted reported intakes

Nutrient	Reported intake	Adjusted intake
Energy (kJ)	8400	10636 (method 2) 8603 (biomarker)
Protein (g)	60	61,1
Total fat (g)	60	53,3
Calcium (mg)	500	615
Iron (mg)	10	14,2
Vitamin A (RE)	800	460
Vitamin C (mg)	60	38

While from the comparison of mean intakes from the QFFQ and the seven-day weighed record (Table 7.8), the QFFQ appears to underestimate total protein, calcium and iron, it does not give an indication of how this difference affects individual intakes, application of the bias now shows how individual intakes are affected as the adjusted values are higher than the reported intakes.

7.3.5 Inter-rater reliability

In examining the reproducibility and validity of the QFFQ so far, only variable characteristics of the subjects, such as gender, age, BMI, and level of urbanisation have been considered. However,

the characteristics of the interviewers, for example their age, personality and way in which they ask questions and record answers may also influence the results of QFFQ. The ideal QFFQ would give the same results for a subject interviewed by different interviewers. For the present study, five interviewers administered the QFFQ. It was therefore necessary to test the agreement between interviewers when interviewing the same five subjects as described in Chapter 5 (5.4.3).

Table 7.27 shows the mean intakes of the five subjects obtained by the five interviewers for energy, total protein, total fat, total carbohydrate, calcium, iron, vitamin A and vitamin C from the five interviewers.

Table 7.27: Mean and standard deviation of nutrient intakes obtained by each interviewer

Nutrient	Interviewers									
	A		B		C		D		E	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Energy (kJ)	9196	1487	8233	2219	9270	1959	9555	1705	9893	2294
Protein (g)	77,7	13,8	73,3	19,2	70,6	16,5	78,7	13,1	80,0	12,4
Fat (g)	69,2	5,4	71,5	19,1	74,0	18,3	80,0	18,1	79,6	14,7
Carbohydrate (g)	315	81,2	257	87,2	313	85,7	305	82,0	330	111
Calcium (mg)	449	168	460	133	539	276	460	133	605	408
Iron (mg)	14,9	6,6	11,9	3,1	15,4	10,3	11,9	2,1	16,8	11,5
Vitamin A (RE)	2717	1242	1651	1417	1706	1371	1853	1253	2226	1554
Vitamin C (mg)	54,6	18,3	34,6	9,6	*118	33,2	61,6	28,4	64,8	32,9

¶SD: standard deviation; *P<0,05

The only significant difference between the mean intakes obtained by ANOVA was for vitamin C, for which the mean intake of interviewer C was significantly higher than that of the four other interviewers. Although not statistically significant, interviewer B appeared to record slightly lower intakes than the other interviewers except for fat and calcium and interviewer E tended to record higher intakes. Spearman rank correlation coefficients ranged between 0,2 and 1,0 for energy; 0,5 and 1,0 for protein; 0,05 and 1,0 for fat; 0,8 and 1 for carbohydrate; 0,4 and 1,0 for calcium; -0,3 and 0,9 for iron; -0,3 and 0,9 for vitamin A and -0,1 and 0,8 for vitamin C. Since the number of observations was very small, only correlation coefficients greater than 0,8 reached statistical significance. With the exception of vitamin C, interviewers A, D, and E appeared to

have the highest mutual correlations. Interviewers B and C tended to have the weakest correlations for energy, calcium, iron and vitamin A.

To gain an indication of the level of agreement across all five interviewers, intra-class correlation coefficients were calculated for each subject using the formula suggested by Dunn (1989). From Table 7.28, it can be seen that agreement was moderate to substantial for all nutrients except vitamin C which gave a slight negative agreement. This can be explained by the significant differences between Interviewer C and the other interviewers (Table 7.27) and also the generally low Spearman rank correlation coefficients obtained for vitamin C.

Table 7.28: Agreement between interviewers

Nutrient	Agreement
Energy	0,784
Protein	0,764
Fat	0,523
Carbohydrate	0,831
Calcium	0,489
Iron	0,446
Vitamin A	0,517
Vitamin C	-0,023

In light of the interpretation of the reproducibility and validity studies and the main dietary intake study, it is important to note that the agreement between the macronutrients was substantial, with carbohydrate, the nutrient which makes up the largest part of the diet having an almost perfect agreement.

7.4 DISCUSSION

In the discussion of the relative validation study, first, the results of the Spearman rank correlation, paired t-tests, Bland-Altman technique and quintile distribution will be compared to those obtained in other studies; second the use and results of the biomarkers will be considered and third, the results obtained using structural equation models will be compared to those obtained from the other statistical procedures and the implications of the differences explored. As reported in the Results section (7.3.1.1) there was a considerable difference in the composition of the sample participating in the validation study compared to the sample of the main dietary intake study regarding the distributions of gender and strata of urbanisation. The implications of these differences will be discussed in Chapter 8, after the results of the dietary intake study have been presented.

7.4.1 Agreement between nutrients

7.4.1.1 Correlation coefficients

The range of Spearman rank correlation coefficients (0,14-0,59) obtained in the present study was similar to ranges reported by several research groups, both in recent years (Borreli *et al.*, 1989; Larkin *et al.*, 1989; O'Donnell *et al.*, 1991; Thompson & Margetts, 1993; Bingham *et al.*, 1994; Frost Andersen *et al.*, 1995; Männistö *et al.*, 1996; Bonifacj *et al.*, 1997) and in earlier studies (Willett *et al.*, 1985; Willett *et al.*, 1987). Coates and Monteihl (1997) summarised the range of correlation coefficients obtained in food frequency questionnaire validation studies in minority populations as 0,4 to 0,7. The ranges reported by the above studies, however, are lower than those reported by a number of other researchers (Nes *et al.*, 1992; Rimm *et al.*, 1992; Lindroos *et al.*, 1993; Bingham *et al.*, 1994; Rothenberg, 1994; Goldbohm *et al.*, 1995). In comparing the results of validation studies, it must be remembered that studies differ with regard to both the test and reference methods used and the methods of analysis. As shown by the summary of validation studies given in Chapter 2 (2.6; Table 2.8), there is considerable variation in correlation coefficients for different nutrients, as well as for different subgroups of the population. Nevertheless, it is useful to compare the correlation results observed in the present study for specific nutrients with other published results.

The correlation coefficient obtained for energy (0,31) falls approximately in the middle of the range of coefficients reported by other authors, being higher than those reported by Larkin *et al.* (1989) for black males (0,23) and black females (0,26), Rimm *et al.* (1992) for male health professionals (0,27) and Männistö *et al.* (1996) for adult females (0,23) and close to those obtained by O'Donnell *et al.* (1991) (0,35), Thompson and Margetts (1993) (0,38 and 0,36 for males and females respectively), Bingham *et al.* (1994) for the Cambridge food frequency questionnaire (0,32) and Bonifacj *et al.* (1997) (0,4). On the other hand it was lower than the coefficient for energy obtained by Nes *et al.* (1992) (0,61) Bingham *et al.* (1994) for the Oxford questionnaire (0,52), Rothenberg (1994) (0,60), Frost Andersen *et al.* (1995) (0,51) and Goldbohm *et al.* (1995) (0,7).

One might have expected the correlation coefficients for the macronutrients to have followed a similar pattern to energy in comparison to other studies. However, this is not always the case. The correlation coefficient obtained for protein (0,3) is greater than those reported by Rimm *et al.* (1992) (0,22), Bingham *et al.* (1994) (0,13 for the Cambridge questionnaire) and Männistö *et al.* (1996) (0,23). For carbohydrate, the correlation coefficient obtained in the present study (0,3) appeared to fall approximately into the mid-range of values obtained by other studies, being larger than values reported by Larkin *et al.* (1989) for black females, O'Donnell *et al.* (1991) for females, Männistö *et al.* (1996) and Bonifacj *et al.* (1997) (0,24, 0,26, 0,25 and 0,25 respectively) but lower than coefficients reported by Larkin *et al.* (1989) for all groups except black females (0,52-0,57), Rimm *et al.* (1992) (0,4), Lindroos *et al.* (1993) (0,43), Thompson and Margetts (1993) (0,54 and 0,52 for males and females respectively), Rothenberg (1994) (0,56) and Goldbohm *et al.* (1995) (0,72).

The correlation coefficient for fat (0,25) is lower than most of the studies cited in Table 2.8, being slightly higher than the coefficient obtained by Larkin *et al.* (1989) for black males (0,23). This could be due to subjects underestimating the amount of fat used in food preparation on the weighed record (see 7.4.2 for further explanation).

There appeared to be very little correlation between the fibre intakes derived from the seven-day weighed record and the QFFQ, with a non significant coefficient of 0,14. This is in marked contrast to other reported coefficients which vary between 0,3 (Männistö *et al.*, 1996) and 0,77

(O'Donnell *et al.*, 1991). Frost Andersen and colleagues (1994), however, also reported a non-significant correlation for fibre intake between a seven-day weighed record and QFFQ. A possible reason for the poor correlation coefficient obtained in the present study is that the time for which the weighed record was kept was too short to reflect usual fibre intakes. According to Nelson *et al.* (1989), a 10-day recording period is necessary to estimate fibre intakes. Other factors may have played a role as several studies with recording periods of seven or fewer days have reported correlation coefficients of greater than 0,5 (Euronut SENECA investigators, 1991; Saba *et al.*, 1995; SENECA investigators, 1996). The generally low intakes and high variation (coefficients of variation of 42% and 38% for the QFFQ and the weighed record respectively) could have contributed to the poor correlation. Also, there is the possibility that some subjects may have over reported their fibre intakes on the weighed record.

Although the correlation coefficient for alcohol (0,53) is in the lower range of reported coefficients for alcohol (0,4 (Petersen *et al.*, 1992) to 0,89 (Goldbohm *et al.*, 1995)), similarly to other studies, it is the highest coefficient obtained among the macronutrients. The relatively good correlation for alcohol may be explained by the large proportion of subjects (66%) who reported no alcohol intake on either the weighed record or the QFFQ.

The highest correlation coefficient (0,59) for the sample as a whole was obtained for vitamin C. This value compares well with coefficients in the range of 0,5 to 0,6 reported from a number of validation studies (Euronut SENECA investigators, 1991; Rimm *et al.*, 1992; Thompson & Margetts, 1993; Bingham *et al.*, 1994; Rothenberg, 1994). In contrast, the coefficient for vitamin A is relatively low (0,22) and not significant. It is, however, interesting that the correlation coefficient for vitamin A is often one of the lowest reported in a given study (Borrelli *et al.*, 1989; Euronut SENECA investigators, 1991; Thompson & Margetts, 1993; Bonnifacj *et al.*, 1997). Also, values as low as 0,09 have been reported (Willett *et al.*, 1985). A possible explanation for the poor correlation of vitamin A is that vitamin A occurs in large amounts in few foods so that the consumption of a vitamin A rich food during the recording period may give a very high intake, not representative of the individual's usual intake. This was well illustrated by one of the female subjects who included liver in her diet on two days during her seven-day record period, resulting in a very high average vitamin A intake for the dietary record. However, if this was converted to the frequency given on the QFFQ (twice a month) her vitamin A intakes recorded by both

methods were similar.

Regarding calcium, the correlation coefficient of 0,24 obtained in the present study was lower than the values in the range of 0,4 to 0,7 obtained by a number of researchers, including the Euronut SENECA team (1991), Rimm *et al.* (1992), Thompson and Margetts, (1993), Bingham *et al.* (1994) and Rothenberg (1994). Nevertheless, it is similar to the result obtained by Männistö *et al.* (1996) (0,26) and only slightly lower than that obtained by Bingham and co-workers (1994) for the Cambridge questionnaire (0,3). Correlation coefficients reported for iron vary from 0,0 (Stuff *et al.*, 1983) to 0,58 (Euronut SENECA investigators, 1991). Although the correlation coefficient in the present study was not significant (0,2; $P > 0,05$), other researchers such as Larkin *et al.* (1989) and Rimm *et al.* (1992) have also reported poor correlations (0,09 and 0,28 respectively).

With the exception of vitamin C, the correlation coefficients for the male subjects were higher than those for the female subjects. This could have been due to the smaller sample size, rather than a real difference in the relationship between the weighed records and QFFQ of the males and females. Another factor which could have contributed to the better results obtained by the males is that most of the male volunteers were from the middle and upper class urban strata and were either students or professionals. Thus, they may have been more accurate in their recording of their food intakes as well as better in recalling intakes for the QFFQ. Studies which have reported correlation coefficients separately for males and females, have shown very similar results for both genders (Larkin *et al.* (1989) for white males and females; Thompson & Margetts, 1993) or higher correlations on some nutrients for females and on other nutrients for males (O'Donnell *et al.*, 1991). The 1991 Euronut SENECA investigators and Delcourt and co-workers (1994) reported consistently higher values for males than for females. This difference was ascribed by Delcourt *et al.* (1994) to a smaller range of intakes among the women, rather than a lower absolute agreement.

Regarding differences in agreement between strata of urbanisation, the middle and upper class urban strata appear to have better agreement between measurements than the rural and informal settlement strata. The better correlations obtained in the middle and upper class urban strata could be ascribed to a higher education level in these strata than in the rural and informal

settlement strata. Only the difference for calcium, however, was significant. Thus, strata of urbanisation do not seem to be a factor in determining the relative validity of the QFFQ.

There did not appear to be a significant influence of age on the correlation between intakes derived from the weighed record and the QFFQ. Although the younger age group generally obtained higher coefficients (except for alcohol) the differences between age groups were not significant. Unfortunately, no studies could be found in the literature which compare the agreement between intakes of different age groups. With reference to Table 2.8, the correlations for the younger age groups (Petersen *et al.*, 1992; Frost Andersen *et al.*, 1995) appear similar to those reported for adults (O'Donnell *et al.*, 1991; Lindroos *et al.*, 1993; Thompson & Margetts, 1993) although slightly lower than the results reported by Goldbohm and co-workers (1995). On the contrary, correlation coefficients for older age groups (Borrelli *et al.*, 1989; Euronut SENECA investigators, 1991; Nes *et al.*, 1992; Bingham *et al.*, 1994; Rothenberg, 1994; SENECA investigators, 1996) are among the highest reported.

The sample was divided into subgroups according to BMI to investigate whether there was a difference in correlation between obese and normal weight subjects, as a number of studies have shown a greater tendency among overweight subjects to underreport dietary intakes (Prentice *et al.*, 1986; Bandini *et al.*, 1990; Hulshof *et al.*, 1995). Although higher correlation coefficients were achieved by the normal weight group, the only significant difference occurred for alcohol. These results seem to be in agreement with the reports of Myers *et al.* (1988) and Lissner *et al.* (1989) who found no association of accuracy of reporting with body weight. Larkin and co-workers (1989), in their sample stratified for gender and BMI, found greater differences in energy intake between the food record and food frequency questionnaire for heavier men, while for women, greater differences were found in the lower BMI group.

When considering correlation coefficients as indicators of relative validity, the question of the level of correlation which represents satisfactory agreement between methods must be addressed. Generally, statistically significant correlation coefficients within the range of 0.4 to 0.7 have been accepted as satisfactory (Margetts & Pietinen, 1997). Writing in a review article in 1987, Bingham concluded that

'...the lack of agreement between measured dietary intake and that estimated from

questionnaires is a consistent finding, the interpretation of this seems to depend on personal opinion.'

From the more recent literature there still appears to be no clear and agreed on cut off point above which the test instrument can be said to be relatively valid. This may be due to the fact that validation studies vary so widely in methodologies, sample sizes and characteristics and test and reference methods that it is not possible to derive a standard acceptable level of correlation. As pointed out by Freedman *et al.* (1991), the higher the correlation coefficient, the better the agreement between methods. A study of the literature, however, (see Table 2.8) shows that few studies achieved correlation coefficients of higher than 0,7 which would be indicative of substantial to high agreement (Dunn, 1989). Block *et al.* (1990), Willett (1990) and Hankin *et al.* (1991) have concluded that correlation coefficients in the range of 0,5 to 0,6 could indicate satisfactory agreement between dietary records and food frequency methods. The Euronut SENECA investigators (1991) concluded that the range of coefficients (0,18-0,78) reported in their study were satisfactory, while Margetts *et al.* (1989) concluded that it was possible to use a food frequency questionnaire with correlations in the order of 0,34 to 0,7. Thompson and Margetts (1993) took significant correlations as satisfactory, while Larkin *et al.* (1989) stated that correlation coefficients of 0,4 and more were relatively high. Romieu *et al.* (1997) compared a food frequency questionnaire with 16-day diet recalls in a Mexican population with a low education level. According to these authors, the range of observed correlation coefficients (0,18 to 0,5) was 'reasonable' for that population. On the other hand, Yarnell and co-workers (1983) who obtained coefficients in the range of 0,27 to 0,41 felt that these were too low to warrant use of their food frequency questionnaire. On the basis of statistically significant correlations, the QFFQ appears to give satisfactory agreement for all the nutrients tested except for fibre, iron and vitamin A. Using similar limits to other studies, for example that of Larkin *et al.* (1989) and Margetts *et al.* (1989) the QFFQ appears to provide satisfactory agreement for energy, protein, vitamin C and alcohol.

7.4.1.2

Differences between mean intakes

On the group level, in the present study, with the exceptions of total carbohydrate and vitamin C, the weighed record yielded higher mean intakes than the QFFQ. This is in agreement with the results of Block *et al.* (1990), Thompson and Margetts (1993), Bingham *et al.* (1994) and

Männistö *et al.* (1996) who obtained higher mean intakes on the dietary record for some nutrients but higher intakes on the food frequency questionnaire for others. These results, however, are in contrast to several other studies which reported higher mean intakes using a food frequency questionnaire or diet history than the dietary record (van Leeuwen *et al.*, 1983; Hankin *et al.*, 1991; Larkin *et al.*, 1989; Rimm *et al.*, 1992; Rothenberg, 1994; SENECA investigators, 1996). The males recorded higher mean intakes for energy and all the nutrients tested on the dietary record except for vitamin A and C. The females overestimated intakes for energy, carbohydrate, fat, iron and vitamin C on the QFFQ. The results for energy for the males are in agreement with the results obtained by Pietinen *et al.* (1988a), Tjønneland *et al.* (1991) and Thompson and Margetts (1993). For the females, the QFFQ seemed to overestimate the mean energy intake slightly, similar to the findings of the volunteer subjects in the study of Thompson and Margetts (1993). The percentage differences between the two methods were lower for the females than for the males, except for alcohol. This is the opposite to what might have been expected from the correlation coefficients which were higher for the males than for the females. Possibly, the agreement between males on an individual level was better than that between females, but on a group level, the agreement was better for females. This may be due to the fact that, although there were more abstainers among the women than the men, there were five women who recorded a very much higher alcohol consumption on the weighed record than they reported on the QFFQ.

In a similar finding to those of Hankin and colleagues (1991) and Larkin and colleagues (1989), the percentage differences between intakes derived from the weighed records and the QFFQ were larger for the vitamins than for energy and the macronutrients (with the exception of protein). Hankin *et al.* (1991) ascribed the large differences in vitamin intakes to the frequent recall of seasonal fruits in the diet history which were not consumed during the record period. This explanation could also apply to the present study. Oranges (the main source of dietary vitamin C and a seasonal fruit) were frequently reported on the QFFQ, but not on the weighed records.

As for correlation coefficients, there is the question as to what percentage of difference is acceptable in a relative validation study. Generally, a difference of 10% or less is indicative of a similar result between measurement instruments (van Leeuwen *et al.*, 1983; Burema *et al.*, 1995). This was achieved for the whole sample for six of the 11 nutrients tested, while the remaining

differences (except for alcohol) were less than 20%. The very high percentage difference for alcohol can be explained by the fact that estimating alcohol intakes using retrospective methods has been found to be very difficult, while prospective recording appears to be more accurate.

When the results of the correlation coefficients and the mean differences between the two methods were compared, there seemed to be some conflict in the outcomes. For example, total protein and alcohol gave significant and relatively high correlation coefficients, but a significant difference with the paired t-test. On the other hand, while the correlations for iron and fibre were very weak, the differences were small and not significant. To explain this, it must be borne in mind that the correlation coefficient shows the linear relationship between the two methods while the comparison of the means assesses agreement on a group basis. Thus, it appears that the QFFQ gave a relatively more valid estimation of some nutrients (iron and fibre) on a group basis while the agreement was better on an individual basis for others (protein and alcohol).

7.4.1.3 Bland-Altman plots

The Bland-Altman plot technique is a fairly recent method for analysing data in validation studies and hence there are few studies with which to compare the results of the present study. The usefulness of the Bland-Altman technique is that it is able to show the presence of constant and proportional bias in a sample, that is, it examines whether agreement between the two methods is consistent over the range of intakes (Thompson & Margetts, 1993). Although the limits of agreement were fairly wide for all nutrients tested (Table 7.9), none of the Spearman rank correlation coefficients were significant, indicating that the differences in intakes were fairly consistent over the range of intakes. Thompson and Margetts (1993), using Bland-Altman plots showed that, for their male subjects, at low energy intakes the food frequency questionnaire gave lower estimates for energy, but at higher intakes it gave higher estimates than the dietary record. This effect was not present in the female subjects. The Bland-Altman plot for energy shown by Körtzinger *et al.* (1997) shows the opposite effect. At low intakes, the dietary record gave lower estimates than the food frequency, and at high intakes the dietary record gave higher estimates. In the present study, there did not appear to be a tendency towards proportional bias, rather the largest differences seemed to be in the mid-range of intakes (Figure 7.8). The plot for vitamin A (Figure 7.9) illustrates a different effect and could explain the low correlation

coefficient. The majority of intakes were low, and the differences between measurement instruments were also relatively small. As the level of intake increased, so did the magnitude of difference in both directions. At exceptionally high intakes (greater than 4000 RE), the intakes obtained from the dietary records were remarkably higher than the QFFQ. Frost Andersen and co-workers (1995) obtained a similar plot for retinol for their sample of Norwegian adolescents.

For all nutrients, there were subjects who showed very wide differences which fell outside the limits of agreement. Exclusion of the outliers could have produced better correlations indicating that for the normal range of intakes agreement was acceptable. Omission of the outliers, however, made very little difference to the correlation coefficients (data not shown).

In a modification of the Bland-Altman technique, Delcourt *et al.* (1994) expressed agreement as the within to between person ratio. The lower the value of this ratio, the better the agreement. The ratio ranged from 1,0 (cholesterol) to 1,7 (total fat and iron). This range is similar to that obtained by Delcourt *et al.* (1994) for their women subjects, but slightly higher than the ratios obtained for the males.

7.4.1.4 Quintile distribution

The proportion of subjects classified into the same or adjacent quintiles on both the weighed record and the QFFQ compares well with reports from several other studies. In addition, the percentages of subjects classified into the same or adjacent quintiles well exceed the proportion of subjects which would be classified into the same or adjacent quintiles by chance alone (20% and 52%) (Kune *et al.*, 1987). When comparing studies, however, differences in classifications must be considered. Bingham *et al.* (1994) reported a range of 34 to 38% of subjects classified into the same quartiles on the dietary record and food frequency questionnaires. Robinson and co-workers (1996) reported a similar range of classification in their study of pregnant women with an average of 35% of subjects assigned to the same quartile for both the food frequency questionnaire and the food diary. Using a tertile system, van Leeuwen and co-workers (1983) were able to classify 53 to 75% of the sample into the same tertile, while Saba and co-workers classified 53% of subjects into the same tertile for fibre. For energy, the percentage of subjects classified into the same quintile (32%) and adjacent quintiles (69%) is the same as that found by

O'Donnell and co-workers (1991). Looking at the classifications for other nutrients, percentages classified into the same quintile vary from 25% for protein (O'Donnell *et al.*, 1991) to 68% for vitamin C (Willett *et al.*, 1985) while classification within adjacent quintiles varies from 61% for total carbohydrate to 93% for alcohol (Männistö *et al.*, 1996). Thus, the QFFQ appears to be able to classify most subjects into similar positions in the distribution as does the weighed record.

7.4.2 Agreement between food groups

The Spearman rank correlation coefficients observed for the food groups appeared lower than those observed for the nutrients. For the food groups, five of the fourteen coefficients were below 0,2 compared with only one of the 11 nutrients. This finding is in agreement with Frost Andersen *et al.* (1995) who observed lower correlations for foods than for nutrients (median correlation coefficients of 0,42 and 0,52 respectively), but in contrast to the results obtained by Goldbohm *et al.* (1994). The lower range of correlation coefficients for food groups can be explained by the higher variation in intakes among foods than among nutrients. If a given food is not consumed during the record period, its intake will be zero. The amount of nutrients, however, may vary but a zero intake is unlikely. The range of correlation coefficients obtained in the present study is similar to some reported ranges (Salvini *et al.*, 1989; Hankin *et al.*, 1991) but lower than others (van Leeuwen *et al.*, 1983; Elmståhl *et al.*, 1996b; Männistö *et al.*, 1996). Direct comparisons of correlation coefficients obtained for foods or food groups among different studies is not very meaningful as the classification of foods into groups varies. Salvini *et al.* (1989) observed higher correlation coefficients for frequently consumed foods than for other foods. The same observation was made in the present study. The highest correlation was obtained for maize meal which is the staple food of the population. Sugar consumption seemed to be fairly constant for individuals, as seen by the high correlation coefficient. Vegetables and fruits are not consumed in large amounts in the study population. Nevertheless, the correlation coefficients for these foods were among the highest. Possibly, the small amounts and limited variety consumed made recall easier.

Frost Andersen and co-workers (1995) and Männistö and co-workers (1996) noted that infrequently consumed foods were difficult to assess. This could help to explain the weak correlations obtained for fish, legumes, samp, eggs and rice (Table 7.11), which were all

consumed infrequently in comparison to maize meal.

The correlation for the milk group was low (0,142) and is reflected in a significantly higher milk intake on the weighed records. It seems that either the QFFQ underestimated milk intakes, or the measuring and recording of the milk intake may have caused subjects to overestimate their intakes. The higher intake of protein obtained by the weighed record is explained by the higher intakes of the meat and milk groups, which were the main sources of animal protein. The intakes of less frequently consumed protein-rich foods such as eggs, legumes and fish were overestimated on the QFFQ.

A finding which has important implications regarding the relative validity of the QFFQ was that, although the maize meal intake was overestimated by the QFFQ, the difference between the two methods was not significant. In addition, the correlation coefficient for maize meal was strong. This means that the QFFQ was able to measure the staple food of the study population satisfactorily. The lower intakes of maize meal and sugar observed on the weighed record were compensated by the higher intakes recorded for other cereals, samp, rice and bread on the weighed record.

The results obtained for fat as a nutrient and fat as a food group appear contradictory in that the nutrient intake is higher on the weighed record than on the QFFQ, but as a food, fat intake is lower on the weighed record. A possible explanation for this is as follows: For the QFFQ, the amount of fat used in food preparation was estimated by the average recipes obtained during the preliminary study whereas for the weighed record, fat used in food preparation was included only if specified on the record. Subjects may have omitted fat from the record or underestimated the amounts of fat used in food preparation, thus giving a lower intake. Fat, as a nutrient, includes fat from meat and milk, both of which were reported in higher amounts on the weighed record, thus compensating for the lower added fat intake recorded on the weighed record.

The QFFQ appeared to overestimate fruit and vegetable intakes in comparison to the weighed record. This difference was reflected in the lower vitamin C intake derived from the weighed records.

According to the Bland-Altman plots, the only food groups showing proportional bias were fruit, rice and sugar. Of note are the negative coefficients for the milk, meat, legume, egg, cereal, fat and sugar groups. This suggests that at higher mean intakes the QFFQ tends to overestimate intakes, as can be seen from the plots of maize meal and sugar (Figures 7.10 and 7.11).

Considering the sd:sm ratios for the food groups, good agreement was obtained for vegetables (0,9), fruit (1,3), maize meal, meat and sugar (1,5). In contrast, agreement appeared low for legumes, rice and samp (2,0).

The percentages of subjects classified within one quintile were lower than the percentages obtained for the nutrients. Nevertheless, with the exceptions of eggs and legumes, 79% or more of the subjects were classified within one quintile for both measurement instruments. This figure compares well with the range obtained by Männistö and co-workers (1996).

From the results of the food group analysis it appears that the agreement between food intakes obtained from the QFFQ and the seven-day weighed record is lower than that obtained for the nutrients. Since intakes of food groups is highly variable within individuals, longer recording periods may be necessary to account for within person variability and thus to reflect the usual intake (Hartman *et al.*, 1990). Hankin *et al.* (1991) who compared a diet history with four weeks of dietary records, suggested that even this length of time was too short to assess usual intakes for a one year period.

7.4.3 Validation by biomarkers

7.4.3.1 24-Hour urinary nitrogen excretion

The high percentage of incomplete 24-hour urine collections (64%) resulted in poor results for the use of urinary nitrogen as a validator of dietary protein intake. The possible reasons for the high number of incomplete collections, especially in the rural stratum, were explained in Section 7.3.2.1. Reasons put forward were that the subjects might not have taken the full dose of PABA tablets, might have taken the tablets at the wrong times or that environmental and methodological factors might have affected the PABA content of the urine collections. Although these factors

may have played a role in some cases, the mean volume and the nitrogen content of the incomplete specimens were lower than the complete specimens. Also, there was much greater variation within the sample of incomplete collections than for the complete collections (coefficient of variation of 66% versus 29%). This seems to indicate that the collections were indeed incomplete rather than only the PABA content being lower.

In explaining the reasons for the incomplete collections, the following factors need to be kept in mind:

- (a) This study was the first attempt to obtain 24-hour urine specimens from a free living African population in South Africa. Thus, the researcher had no idea as to how the volunteers would react or what the level of compliance would be. The instructions given to the volunteers were based on those used by Bingham *et al.* (1992) in a British population. A different approach might have been needed for the African population.
- (b) As pointed out in the discussion of the reproducibility results (Chapter 6), the whole research set up was something new to most of the subjects and the request to collect their urine for 24-hours might have seemed very strange. The subjects may not have understood the purpose of the collection or the importance of ensuring that all specimens were collected. This possibility is supported by the fact that the best response was obtained from the middle and upper class urban strata where the level of education was higher.
- (c) The circumstances under which the volunteers had to collect their urine specimens may have been difficult for many, even if they had fully intended to comply. Especially in the rural and informal settlement areas, toilets are shared by a number of families, making privacy difficult. There may not have been a safe, discrete place in which to leave the bottles during collections and volunteers might have had to explain what they were doing, not only to their families, but to curious outsiders as well. Additional difficulties may have been experienced by volunteers at their place of work or school, in keeping the specimens during the day and carrying them to and from work. For example, one of the scholars was only able to bring his urine collection from the previous night. He had left

bottle in the school toilet during the day and somebody had thrown it out.

Ways in which these problems could have been overcome need to be explored. A pilot study should have been undertaken in the study population to identify problems and to try out different approaches. However, the practicalities and expense of undertaking such a study made this impossible. Although detailed instructions were given to the subjects, possibly more time should have been spent on explaining the reasons for the collections, for taking the PABA and for collecting complete 24-hour specimens. A solution suggested by Bingham *et al.* (1992) was to have told volunteers that a second collection would be required if the first was found to be incomplete. Also, the volunteers should have been told that they would only be paid for complete collections. In addition, the effectiveness of PABA as a marker of completeness needs to be assessed in the study population. Other researchers have noted that PABA has some drawbacks. Over collection cannot be detected, volunteers may forget or refuse to take the tablets, meal times may interfere with the PABA absorption and excretion (Knuiman *et al.*, 1986) and renal impairment reduces excretion (Bingham *et al.*, 1992). Johansson and co-workers (1992), in their study of biological markers for validating dietary intake four times during a 12 month period, attempted to use a comparison of water intake to water excretion as an indicator of completeness. These authors reported, however, that it was extremely difficult to measure water intake and excretion via the skin and lungs and that no conclusions could be drawn about the completeness of collections using this method.

Although the percentage of incomplete collections in the present study was high, other studies have also reported poor compliance. O'Donnell and co-workers (1991) reported a similar rate of incomplete collections (65%) to the present study, 35% of the collections in the study of Petersen and co-workers (1992), 29% of 63 collections obtained by Bingham and co-workers (1992) were incomplete and 23% and 24% of those in the study of Porrini *et al.* (1995) and Rothenberg (1994) respectively were incomplete. Higher percentages of complete collections ranging from 89% for 28 collections by eight subjects under metabolic unit conditions (Bingham *et al.*, 1995) to 95% in a free living sample (Knuiman *et al.*, 1985) have been reported.

There was no meaningful correlation between reported protein intake from the QFFQ and calculated urinary protein excretion either for all 88 specimens ($r=-0.07$) or for the 32 complete

specimens ($r=0,01$). These results compare poorly with other studies which have compared calculated urinary protein excretion with reported dietary protein intake derived from food frequency questionnaires. Rothenberg (1994) obtained a correlation coefficient of 0,19 for all specimens and of 0,27 when incomplete specimens were excluded from the analysis, while Porrini *et al.* (1995) reported a correlation coefficient of 0,45 and O'Donnell *et al.* (1991) reported a coefficient of 0,34. Bingham *et al.* (1995) obtained correlation coefficients of 0,24 and 0,15 between the Oxford and Cambridge food frequency questionnaires respectively and eight, 24-hour urine specimens. Considering the 46 subjects who provided both seven-day weighed records and 24-hour urine collections, the Spearman rank correlation coefficient was slightly higher between the weighed record and calculated urinary protein (0,03).. This value was also markedly lower than correlations reported in other studies for seven-day weighed records (Rothenberg *et al.*, 1994; Porrini *et al.*, 1995). In the validation of a 16-day weighed record with eight 24-hour urine samples, Bingham and colleagues (1995) reported correlation coefficients between 0,78 and 0,99. O'Donnell *et al.* (1991) who used four, 24-hour urine collections to validate 16-day weighed records achieved a correlation coefficient of 0,56.

In contrast to the weak correlation, the mean ratio of urinary nitrogen to dietary nitrogen (UN:NI) calculated from the QFFQ compared more favourably to other studies. For the complete specimens the ratio was 0,8 which was established by Bingham *et al.* (1985) as the desired ratio indicating agreement at an individual level. The ratio for the incomplete collections was slightly lower at 0,7, while for the weighed records it was 0,64. Bingham and co-workers (1995) obtained a UN:NI ratio for eight urine collections compared to 16-day weighed records of 0,91 while Black and colleagues (1995) reported a ratio of 1,15 between five, 24-hour urine collections and 21-day dietary records. The percentage of subjects classified into adjacent quintiles for the weighed record (74%) was slightly higher than that of the QFFQ (65%). This finding and the slightly stronger correlation coefficient suggest that the urinary nitrogen excretion might have been a better indicator of dietary intake from the weighed records than from the QFFQ. Since both sets of results are weak, however, no conclusion can be drawn from the present data.

A ratio of urinary nitrogen excretion to dietary nitrogen intake of greater than one indicates the possibility that the intake has been underestimated (Bingham, 1991). Significantly fewer

underreporters were identified using this ratio than using the energy intake to BMR ratio (Table 7.19) for both the QFFQ and the seven-day weighed record. Compared to the QFFQ, a smaller proportion of subjects was identified as possible underreporters using the weighed records.

A reason for the poor results is that one, 24-hour urine collection cannot be expected to reflect habitual dietary protein intake as the QFFQ and the seven-day weighed records are supposed to do. As pointed out by Bingham (1991), intra individual variation in urinary nitrogen excretion is high. Thus, on a daily basis, urine nitrogen correlates poorly with dietary nitrogen. Although satisfactory results have been obtained with three (Rothenberg, 1994; Porrini *et al.*, 1995), four days (O'Donnell *et al.*, 1991; Visser *et al.*, 1995) and five (Black *et al.*, 1995) days of urine collections, Bingham (1991) has recommended that, to estimate nitrogen excretion within $\pm 5\%$ standard error, eight days of collections are needed. Practically, collection of more than one 24-hour urine sample in the present study would have been difficult. As was seen from the reproducibility study, the tracing of subjects was extremely time consuming and difficult. The logistics of arranging for collections, providing the equipment and collecting the specimens would have been virtually impossible, especially in the rural and farm areas. To have done this at the same time as continuing the data collection of the main THUSA study, would have required additional field workers, laboratory assistants, transport and accommodation which would have been beyond the budget of the study. The only feasible option would have been to recruit a small sample of educated and motivated volunteers from Potchefstroom to participate in the collection of four to eight 24-hour urine specimens, the completion of the QFFQ and the seven-day weighed record. This would have been a biased sample and not representative of the THUSA sample. Nevertheless, it might have provided more meaningful results.

7.4.3.2

Estimated basal metabolic rate

The ratio of energy intake to BMR is an objective way of assessing whether reported energy intakes are reasonable in terms of energy requirements (Bingham, 1991; Goldberg *et al.*, 1991). The ratio below which energy intakes have been taken as invalid has differed among studies (see Table 2.6), but most researches have set the cut off ratio between 1,1 (Price *et al.*, 1997) and 1,54 (Bingham *et al.*, 1995). Using the values proposed by Goldberg *et al.* (1991) for sample sizes of 74 and 144 for the validity and reproducibility samples respectively, the required cut off limit

is 1,5 and for the total dietary intake sample (N=889) the limit is 1,53. In the present study, however, considering the limitations of the use of the Schofield equations for the calculations of BMR, the ratio of 1,2 suggested by Bingham (1991) was taken as the lowest reasonable EI:BMR.

Of the subsamples shown in Table 7.19, higher EI:BMR ratios were obtained for the seven-day weighed records than for the QFFQ, with the exception of the 24-hour urine sub sample. Part of the reason for the better ratios for the weighed records could have been the much smaller sample sizes, and the fact that the sub samples could have been biased towards the more educated and motivated subjects. However, within the two weighed record subsamples (seven-day weighed record plus 24-hour urine collection and seven day weighed record), the mean reported energy to BMR ratios observed for the weighed records were higher than for the QFFQ. For the males, this difference reached significance in both cases ($P < 0,05$). This result is in contrast to that of Rothenberg (1994) who obtained lower EI:BMR ratios for a four-day weighed record in comparison to a semiquantitative food frequency questionnaire in elderly male and female subjects. The mean ratios for EI:BMR obtained in the present study were lower than the cut off values of 1,5 to 1,53 derived by Goldberg *et al.* (1991) for underreporting based on estimated BMR and the appropriate sample sizes. Nevertheless, these values are comparable to several other studies which used weighed records (Livingstone *et al.*, 1992; Nes *et al.*, 1992; Bingham *et al.*, 1995; Price *et al.*, 1997) and higher than several others (Rothenberg, 1994; Cole *et al.*, 1997; Macdiarmid & Blundell, 1997). The only notably higher reported ratios (1,92 and 1,77 for males and females respectively) were obtained by Haraldsdóttir and Sandström (1994) in a very strictly controlled dietary intervention programme with young, highly motivated subjects. It must be noted that the measurement of BMR differed among studies, in some being measured by DLW (Livingstone *et al.*, 1992) or indirect calorimetry (Nes *et al.*, 1992) and in others being estimated by the Schofield equations (Price *et al.*, 1997), the Food and Agricultural Organisation/World Health Organisation/United Nations University (FAO/WHO/UNU) equations (Cole *et al.*, 1997) or by the DHSS equations (Rothenberg *et al.*, 1997). Thus, differences in the results reported may be due to BMR measurement techniques, the dietary assessment instrument, the accuracy with which the respondents reported intakes or a combination of these factors.

Regarding the QFFQ, the mean EI:BMR ratio obtained by the 88 subjects who kept 24-hour urine samples was similar to the range of ratios obtained for elderly subjects by Rothenberg (1994) and Rothenberg and co-workers (1997) and higher than that reported by Wheeler *et al.* (1994) for three different formats of a semiquantitative food frequency questionnaire. The ratios observed for the reproducibility and weighed record subsamples and the entire dietary intake sample, however, were in a similar range to that observed by Wheeler *et al.* (1994). An interesting similarity between the ratios obtained in the present study and those reported for males and females separately, is that in all cases the ratio for males is higher than that for females (Livingstone *et al.*, 1992; Rothenberg, 1994; Price *et al.*, 1997; Rothenberg *et al.*, 1997). Again, the observed differences between genders may be due to more accurate reporting by the males, but may also be because BMR measurement or estimation is more precise.

The percentages of underreporters identified by a EI:BMR ratio of below 1,2 were highest for the entire dietary intake sample and weighed record subsamples for the QFFQ (40%) and lowest for the weighed records (28%). The percentage of underreporters for the weighed records is within the range reported by several other researchers (Cole *et al.*, 1997; Hirvonen *et al.*, 1997; Price *et al.*, 1997). On the other hand, the percentage of underreporters identified for the QFFQ is somewhat higher than the percentages obtained for semiquantitative food frequency questionnaires (Wheeler *et al.*, 1994) and dietary histories (Rothenberg *et al.*, 1997). In comparison to large population based surveys, the percentage of low energy reporters in the total sample (40%) was almost double that of 23% found in the National Health and Nutrition Examination Survey III (NHANES III) (Briefel *et al.*, 1997). The NHANES III study, however, used a lower limit of 0,9 and thus results are not directly comparable. The percentage possible underreporters among the females in the total sample (41%) was lower than the percentage for women in a British survey which also used 1,2 as a lower limit (46%) but that of the men was considerably higher (40 % and 29%) (Pryer *et al.*, 1997). Körtzinger and colleagues (1997), who used a limit of energy intake of 20% lower than energy expenditure measured by indirect calorimetry to identify underreporters, found that 48% of 50 subjects underreported their energy intake on both a seven-day estimated diet record and a dietary history. Of note is the higher percentage of underreporters identified for the QFFQ than for the weighed records in the subjects who completed the weighed records. It seems that, for these subjects, the weighed record was a more accurate measure of energy intake than the QFFQ.

Several authors have questioned the validity of the use of the Schofield equations (Schofield, 1985) for the estimation of BMR (Hayter & Henry, 1994; Shetty *et al.*, 1996; Cole *et al.*, 1997; Piers *et al.*, 1997; Rothenberg *et al.*, 1997) on the basis that these equations have been found to overestimate BMR, in both tropical and temperate regions (Owen *et al.*, 1987; de Boer *et al.*, 1988; Valencia *et al.*, 1993; Shetty *et al.*, 1996; Piers *et al.*, 1997). In a recent study on 14 elderly subjects in Cape Town, the mean predicted BMR from the Schofield equations was seven to 14% higher than BMR measured using the heart rate monitoring technique for males and females respectively (Charlton & Lambert, 1998). (For a detailed discussion of the limitations of the Schofield equations, the reader is referred to Shetty *et al.*, 1996). If these findings are applied to the present study, the true BMR of the subjects may have been lower, and thus the EI:BMR ratios closer to the limits set for minimal activity (Goldberg *et al.*, 1991). As a result the percentage of possible underreporters would have been lower. Unfortunately, as there are no known studies which have measured BMR in African populations similar to that of the North West province, this speculation cannot be verified.

7.4.3.3 Comment on underreporting

Both the urinary nitrogen excretion and the BMR were used in an attempt to quantify the incidence of possible underreporting in the study sample for both the seven-day weighed record and the QFFQ. Combining the two methods showed that, for the seven-day weighed record, only three (7%) subjects could be classified as underreporters by both methods. For the QFFQ, out of the sample of 88 subjects, 15% were identified as possible underreporters by both methods. Black and co-workers (1995) identified six of 11 subjects as having provided invalid dietary records using both methods.

Recently, a number of papers have been published expressing concern about the effects of underreporting on the validity of dietary surveys and the characteristics of subjects likely to report implausible intakes (Haraldsdóttir & Sandström, 1994; Macdiarmid & Blundell, 1997; Hirovonen *et al.*, 1997; Voss *et al.*, 1998). The most frequently identified factor related to underreporting has been obesity (Heitmann, 1993; Bingham *et al.*, 1994; Hirvonen *et al.*, 1997; Price *et al.*, 1997; Voss *et al.*, 1998). Other factors associated with underreporting include age (Hirovonen *et al.*, 1997), being female, (Klesges *et al.*, 1995; Hirovonen *et al.*, 1997), low education level

(Klesges *et al.*, 1995), high education level (Hirovonen *et al.*, 1997) and previous weight status (Black *et al.*, 1995; Price *et al.*, 1997). Although the present study was not designed to identify the characteristics of possible underreporters, analysis of the dietary intake study data showed the lowest percentage (30%) of possible underreporters among the youngest subjects and the subjects with low BMI. Although the difference in the incidence of underreporting was not significantly different between the normal and high BMI subjects, this finding seems to be in agreement with the above reports of the relationship of high BMI to underreporting. Of importance to the present study was the finding of similar percentages of possible underreporters in all strata of urbanisation. This implies that, although underreporting was present, its effect was fairly evenly distributed among strata.

7.4.4 Structural equation models

In most published validation studies making use of biomarkers, the correlation coefficients of the biomarkers and the dietary intake measurement instrument are reported separately (O'Donnell *et al.*, 1991; Rothenberg, 1994; Black *et al.*, 1995; Bingham *et al.*, 1995; Porrini *et al.*, 1995). It is not always clear how the results of the biomarkers relate to the correlation between the test and reference methods. The statistical method, using structural equation models (SEM), proposed by Kaaks *et al.* (1994b) combines the findings obtained from the biomarker with those from the correlation of the reference and test methods to give a single validity coefficient for a given nutrient. Also, the use of structural equation models, without the presence of a biomarker, takes account of the possibility that the random errors between measurement instruments and replicate measures are correlated, thus providing a more accurate measure of relative agreement than the Spearman rank correlation coefficient (Kaaks *et al.*, 1994b). An additional advantage of the structural equation model technique is that it gives an estimate of the constant and proportional bias in the measurement of the intake of a given nutrient and provides a means of applying the findings of the validation study to the dietary intake results of the main study.

The method proposed by Beaton (1991) to estimate the components of variance of the QFFQ was also applied to determine whether results obtained would be similar to those of the SEM. In the light of the reservations expressed about the use of the correlation coefficient in validation studies (Bland & Altman, 1986; Hebert & Miller, 1991; Bellach, 1993; Delcourt *et al.*, 1994), it

was hoped that either or both these methods would provide a feasible and useful alternative to the use of the Spearman rank correlation coefficient.

As expected, the first method of Kaaks *et al.* (1994b) by which the mean intake obtained from the seven-day weighed record was compared to the QFFQ, yielded results very similar to those obtained by the application of the Spearman rank correlation (Table 7.23). When each day of the seven-day weighed record was treated as a separate replicate, the values of the correlation improved for all nutrients tested. An interesting finding resulted from the use of the five week days of the dietary record instead of the full seven-day record. The original reason for using only five days was that there was little variation in dietary intakes during the week, but dietary intakes over the weekend and especially on Sundays varied considerably. It was speculated that by excluding Saturday and Sunday, the within person variation would be decreased, and a stronger correlation between the QFFQ and the unknown true intake would be observed. On the contrary, although using a five-day record produced stronger correlations than using the mean intake of the weighed record, the use of the full seven-day record with each day treated as a separate observation produced better results. Possibly, the better results justify the use of a seven-day recording period rather than a shorter period. Alternatively, the better results could be interpreted as indicating that the QFFQ was able to reflect the variability in the diet resulting from changes in eating patterns over the weekends. In the remaining discussion, only the results using the full seven-day weighed record will be considered.

An advantage of the SEM is that it provides a measure of the constant and proportional bias present in the measurement instrument (Kaaks & Riboli, 1997). As seen earlier, (7.4.1.3), Bland-Altman plots (Bland & Altman, 1986) may also be used to identify constant and proportional bias based on the differences in intakes between the two methods. The SEM estimates bias between the true intake and the intake derived from the QFFQ and by making use of more parameters may give a more robust estimation. Regarding proportional bias, SEM identified significant bias in all nutrients tested with the exception of vitamin C. Importantly, the inclusion of BMR in the calculation, removed the proportional bias from the estimate of energy. Unfortunately, because of the unreliability of the urinary nitrogen data, no conclusion could be drawn about the effect of including a biomarker on protein. Likewise, constant bias was observed for all nutrients, except vitamin C. In practical terms, the presence of proportional bias is more important in

dietary surveys than constant bias. Constant bias does not affect the ranking of individuals within the distribution, nor will it affect the comparison of intakes among subgroups of the sample. For example, if the QFFQ overestimated protein intake consistently by 10 g, the intakes of all subjects would be 10 g higher than the true intake. Proportional bias, however, means that as the true intake increases the QFFQ proportionally underestimates or overestimates the true intake. This will affect both the ranking of individuals within the distribution as well as comparisons among subgroups. It cannot, therefore, be assumed that the QFFQ gives the same reflection of true intake for all nutrients or for all levels of intakes. The advantage of the SEM, is that the estimates of constant and proportional bias provide a means of adjusting reported intakes to possibly give a closer estimate of true intakes. As can be seen by the example in Table 7.26, using hypothetical intakes, the QFFQ underestimated energy, calcium and iron and overestimated total fat, and vitamin A while for an intake of 60 g protein was accurately estimated.

The modified method of Beaton (1991) yielded higher correlations between the QFFQ and true intake than were obtained by the Spearman rank correlation, but lower values than the SEM. This may indicate that the SEM, by making use of more parameters, is able to give a more precise estimate of validity. An advantage of the method of Beaton (1991) is that it also shows the relationship between the reference method and the true intake, which in the present study was close to perfect for all nutrients tested (0,79 to 0,92). It may be simpler to apply, requiring only the within and between person variances, calculated by the analysis of variance. In contrast, SEM requires fairly sophisticated software and statistical knowledge to implement. In a recent report, Ocké and Kaaks (1997) proposed a simplified method, known as the 'method of triads' to estimate the validity of a test measure. This method requires a biomarker, but is based on correlations between methods and does not require complicated calculations. An extension of the comparison of statistical methods in the present study would be to apply the method of Ocké and Kaaks (1997) and to compare the results to those obtained by the methods of Kaaks *et al* (1994b) and Beaton (1991).

To test the feasibility of applying SEM to food group intakes, the modified method of Kaaks was applied to the maize meal intake. There was little difference between the results obtained by the Spearman rank correlation and the SEM for direct comparison between the QFFQ and the seven-day weighed record or between the repeat administrations of the QFFQ. When all three methods

were combined in a simulation of the inclusion of a biomarker, the relationship between the QFFQ and true intake improved to become very strong (0,8) implying that the QFFQ is able to give a close reflection of the true intake. As pointed out in the Results section, however, because of the small size used in these calculations, the results need to be interpreted with caution. Further testing of the SEM and other methods using food groups instead of nutrients is necessary to establish simple and reliable methods for estimating the relationship between true food intakes and intakes reported on measurement instruments.

7.5 SUMMARY AND CONCLUSIONS

The objective of the validation study was to determine whether the information obtained by the QFFQ would be a true reflection of the dietary intakes of the population of the North West province. The intakes derived from the QFFQ were compared with those obtained from seven-day weighed records kept by a sample of 74 volunteers. Both nutrient and food intake results were compared using several statistical techniques including the Spearman rank correlation, paired t-test, Bland-Altman technique, quintile distributions and structural equation models. In addition, biomarkers in the form of estimated basal metabolic rate and urinary nitrogen excretion were used as independent measures of relative validity. The very high inter subject variation and poor correlation of the calculated urinary protein with dietary protein, possibly due to poor compliance or too few days of collection, meant that these results could not be used as a measure of relative validity, nor could they be applied meaningfully to the SEM. The application of several statistical tests to the data gave rise to a range of results which must be interpreted together in order to arrive at a conclusion about the relative validity of the QFFQ. According to Little *et al.*, (1997), the following combination of results would indicate high relative validity of the QFFQ: a significant correlation coefficient, no significant difference between mean intakes, no bias as indicated by a non-significant correlation on the Bland-Altman Plot and a high percentage of subjects classified into the same or adjacent quintiles on the distributions of the QFFQ and the seven-day weighed record. In addition, the proportional bias calculated by the SEM should be close to one and the constant bias close to zero. The results are summarised in Table 7.29.

Table 7.29: Summary of relative validation results

Test	Criterion for relative validity	Nutrient										
		Energy	Protein	CHO*	Fat	Chol*	Fibre	Calcium	Iron	Vit A*	Vit C*	Alcohol
A. Relative validity according to the ability of QFFQ to rank subjects within the distribution similarly to the reference method												
Spearman R	Significant (P<0,05)	Y	Y	Y	Y	Y		Y		Y	Y	Y
Quintile distribution	‡>70% subjects in same / adjacent quintiles			Y	Y	Y	Y	Y	Y	Y	Y	Y
B. Relative validity in terms of group agreement												
Paired t-test	Difference not significant	Y		Y	Y	Y	Y	Y	Y	Y	Y	
c. Estimation of bias												
Bland-Altman plot	**No bias	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Proportional bias using SEM	β_Q close to 1			Na		Na	Na				Y	Na
Constant bias using SEM	α_Q close to 0			Na		Na	Na				Y	Na
D. Estimated correlation with true intake (based on range of coefficients obtained by SEM)												
$\rho(Q,T)$	†Range moderate or stronger	Y¶	Y	Na		Na	Na			Y	Y	Na

Y: nutrient meets criterion; Na: Not tested; * CHO: carbohydrate; chol: cholesterol; Vit A: vitamin A; Vit C: vitamin C. ** according to Spearman r between mean of intakes and difference between intakes; ‡arbitrary value calculated as the mean of the percentages reported by Willett *et al.* (1985) and Männistö (1996); ¶ energy includes $\rho(Q,T)$ calculated using basal metabolic rate; †ranges include results from calculations using the modified method of Beaton (1991).

From the results obtained in the present study, it is clear that the relative validity of the QFFQ cannot be thought of as a single entity which applies to the whole QFFQ. The relative validity varies among nutrients and according to the aspect of the QFFQ being tested. In terms of the ability of the QFFQ to rank subjects within the distribution similarly to the reference method, the QFFQ performed satisfactorily for total carbohydrate, total fat, cholesterol, calcium, vitamin A, vitamin C and alcohol. Energy, protein, fibre and iron met the criterion of only one test. Therefore, although the QFFQ may be able to classify subjects relatively accurately within the distribution, the results obtained in the dietary intake study need to be interpreted with caution.

On the level of group agreement between the QFFQ and the seven-day weighed record, the QFFQ significantly underestimated mean total protein and alcohol intakes. Energy, total fat, cholesterol,

fibre, calcium, iron and vitamin A were slightly underestimated by the QFFQ. In the light of the constant and proportional bias identified by the SEM for all parameters tested (except energy and vitamin C), however, it cannot be assumed that the degree of underestimation is consistent at all levels of true intake. As demonstrated by the Bland-Altman plots, there is a tendency for the differences in intakes obtained by the two methods to increase as the intake increases. As will be demonstrated in Chapter 8, the presence of proportional bias may have important implications for the interpretation of the results obtained by the main dietary intake study. Finally, in relation to the latent true intake, four of the nutrients tested (energy, protein, vitamin A and vitamin C) showed a moderate or stronger correlation to the true intake. If this result ($\rho(Q,T)$) is taken together with the results obtained on the other tests, it seems that satisfactory relative validity was obtained for energy, protein, vitamin A and vitamin C. Although there appeared to be a degree of validity for total fat, calcium and iron, this was not confirmed by the SEM. As SEM was not applied to carbohydrate, cholesterol, fibre and alcohol, the conclusions regarding the relative validity of these nutrients can only be based on the other tests. Carbohydrate and cholesterol appeared to meet all the criteria for relative validity, while fibre and iron performed poorly with the Spearman rank correlation coefficient.

As only energy and 10 nutrients were tested for relative validity, it cannot be assumed that the measurement of all nutrients by the QFFQ would yield similarly valid results. However, the nutrients selected are those which are most representative of the total dietary intake and thus the results could be applied to the dietary intake as a whole. Although agreement between the QFFQ and the seven-day weighed records was poorer for food groups than for nutrients, the QFFQ did appear to be able to measure the intake of staple and frequently consumed foods satisfactorily.

The QFFQ developed for the assessment of the dietary intakes of the African population of North West province appears to give relatively valid results for energy, the macronutrients, calcium, vitamin A and vitamin C. Results of intakes of fibre and iron need to be interpreted with caution. Since the purpose of the THUSA study was to investigate the effect of transition on the development of non communicable diseases associated with urbanised lifestyles, the most important dietary factors to consider are energy and macronutrient, especially fat, intake. It is encouraging that satisfactory levels of relative validity were achieved for these factors. Since fibre intake also plays an important role in NCDs and intakes in African populations have been

declining (Walker *et al.*, 1994), the poor results obtained were disappointing and thus the fibre intakes obtained in the main dietary intake study must be interpreted with caution.

The results of the present study highlight the need for validation to be tested by more than one method, as pointed out by several authors (Bingham, 1991; Willett, 1991). Considering the difficulties experienced in the collection of 24-hour urine specimens and the poor results obtained, estimated BMR appeared to be the most practical biomarker in the African population of North West province.

7.6 RECOMMENDATIONS

The recommendation suggested below apply only to the relative validation study itself. Recommendations for the improvement of the QFFQ based on the findings of the relative validation study will be dealt with in Chapter 8.

7.6.1 The seven-day weighed food record as reference method

- (a) The need for literate volunteers restricted the use of the seven-day weighed record which resulted in a biased sample. Alternatives to weighed records, such as a series of 24-hour recalls or direct observation need to be considered for use in populations with low levels of literacy. The use of an estimated record or the use of the FPPB to estimate portion sizes as done by Hankin *et al.* (1991) may be more practical for populations with low literacy levels.
- (b) The burden imposed on the volunteers by keeping a weighed record for seven days resulted in decreasing accuracy towards the end of the recording period. The feasibility of using a shorter recording period but more subjects or splitting recording between two or more shorter periods, as done by Frost Andersen *et al.* (1995), needs to be investigated. As pointed out in the discussion, the seven-day recording period may not have been representative of the usual diet. Thus, spreading recording over six months or a year (see for example O'Donnell *et al.* (1991) and Bingham *et al.* (1994)) or administering 24-hour recalls during each season should be considered.

7.6.2 Biomarkers

- (a) Methods for collecting more reliable 24-hour urine samples need to be tested on small samples (as already discussed). In addition, the stability of PABA under different field conditions should be investigated.
- (b) More information is needed on energy requirements and expenditures of African populations. There is a need to determine BMR by direct means such as DLW or calorimetry in order to derive estimation equations more appropriate for the population. The inclusion of measurement of lean body mass in addition to weight may also give more accurate estimations of BMR (Astrup *et al.*, 1990).

7.6.3 Analysis of data

In the light of the development of numerous techniques for the analysis of validation data, there is a need to standardise techniques as well as to set standard levels which identify relative validity. The need for international standardisation in the methodology and reporting of validation studies has been emphasized in editorials in the *European journal of clinical nutrition* (Garrow, 1995) and the *British journal of nutrition* (Southgate, 1995). Collaboration between established research centres and groups working in developing countries could contribute to the improvement of the quality of dietary research in these areas as well as giving established centres an understanding of the practical difficulties involved in conducting dietary intake research in areas lacking the infrastructure and technologies of first world countries.

CHAPTER 8

THE DIETARY INTAKE STUDY

8.1 INTRODUCTION

The preceding chapters have presented the methods and results of the preliminary studies (Chapters 3 and 4), the methods common to the main dietary intake, reproducibility and relative validation studies (Chapter 5) and the results of the latter two studies (Chapters 6 and 7). In this chapter the results of the main dietary intake study will be presented and discussed. As noted in Chapter 1, the main purpose of the dietary intake study in the context of this thesis was to test the QFFQ and FPPB under field conditions. Therefore, the results are not presented in great detail, nor are associations between dietary intakes and health parameters examined. The results of the acculturation questionnaire are presented first to clarify the strata of urbanisation. In order to provide the reader with the background against which food intake occurs, the meal and snacking patterns of the sample are described in Section 8.2.3. Sections 8.2.4 to 8.2.8 present the reported nutrient and food intakes in terms of the differences among the five strata of urbanisation. The results are discussed in Section 8.3.

8.2 RESULTS

8.2.1 Sample description

A total of 910 subjects was interviewed during the dietary intake study. Of these, the data of 20 subjects (2%) were excluded from the analyses because the energy intakes of 17 exceeded the sample mean plus two standard deviations (17000 kJ) and those of three were less than sample mean minus two standard deviations (1700 kJ). The final dietary intake sample comprised 890 subjects, 62% (552) of whom were females and 38% (338) males. Table 8.1 summarises the sample distribution according to stratum of urbanisation, age group and gender,

Table 8.1: Sample distribution according to stratum of urbanisation, gender and age group

Stratum	Gender	Age group (years)					Total N %
		15-24,9 N %	25-34,9 N %	35-44,9 N %	45-54,9 N %	54-65,9 N %	
Rural	Males	27 3,0	11 1,2	15 1,7	11 1,2	14 1,6	78 8,8
	Females	30 3,4	28 3,1	32 3,6	32 3,6	31 3,5	153 17,2
	Total	57 6,4	39 5,3	47 5,3	43 4,8	45 5,1	231 26,0
Farms	Males	16 1,8	15 1,7	11 1,7	19 2,1	8 0,9	69 7,8
	Females	11 1,2	15 1,7	14 1,6	13 1,5	6 0,7	59 6,6
	Total	27 3,0	30 3,4	25 3,3	32 3,6	14 1,6	128 14,4
Informal settlement	Males	14 1,6	7 0,8	6 0,7	8 0,9	6 0,6	41 4,6
	Females	17 1,9	27 3,8	18 2,0	10 1,1	8 0,9	80 9,0
	Total	31 3,5	34 4,6	24 2,7	18 2,0	14 1,5	121 13,6
Middle class urban	Males	18 2,0	17 1,9	11 1,2	16 1,8	9 1,0	71 8,0
	Females	18 2,0	50 5,6	30 3,4	28 3,1	16 1,8	142 16,0
	Total	36 4,0	67 7,5	41 4,6	44 4,9	25 2,8	213 24,0
Upper class urban	Males	35 3,9	20 2,2	15 1,7	7 0,8	2 0,2	79 8,9
	Females	32 3,6	31 3,5	33 3,7	19 2,1	3 0,3	118 13,3
	Total	67 7,9	51 5,7	48 5,4	26 2,9	5 0,5	197 22,1
TOTAL	Males	110 12,4	70 7,9	58 6,5	61 6,9	39 4,4	338 38,0
	Females	108 12,1	151 17,0	127 14,3	102 11,5	64 7,2	552 62,0
	Totals	218 24,5	221 24,9	185 20,8	163 18,3	103 11,6	890 100,0

*%= per cent total sample

The purpose of the present study was specifically to investigate the effects of urbanisation on dietary intakes. Nevertheless, in order to interpret the dietary intake results, it is necessary to know something about the nutritional status of the subjects and possible differences in nutritional status between strata. Table 8.2 summarises the means and standard deviations of BMI across strata according to age groups.

Table 8.2: Mean and standard deviation of body mass index for females and males according to age group and stratum of urbanisation (N=890)

Age group (years)	†Stratum	Females (N=552) BMI*		Males (N=338) BMI*	
		Mean	‡ SD	Mean	‡ SD
15 - 24,9	R	22,3	4,0	19,2	2,4
	F	21,6	4,4	19,5	2,0
	IS	24,9	4,6	20,1	2,0
	MCU	24,8	5,4	19,9	1,3
	UCU	23,3	4,7	20,1	2,0
25 - 34,9	R	25,0	5,0	22,8	6,6

	F	24,2	5,4	21,3	2,5
	IS	27,7	7,5	20,0	2,4
	MCU	26,9	6,1	21,5	2,2
	UCU	27,5	6,2	24,9	3,7
35 - 44,9	R	28,5	7,2	20,9	2,8
	F	28,9	7,6	20,3	2,8
	IS	28,7	7,2	22,5	3,8
	MCU	29,2	6,9	20,6	2,5
	UCU	29,1	5,5	23,9	2,7
45 - 54,9	R	25,0	6,6	25,5	6,8
	F	26,6	4,1	21,5	4,1
	IS	27,8	8,4	20,0	3,0
	MCU	29,8	8,9	22,4	3,0
	UCU	31,4	5,6	26,3	5,7
55 - 64,9	R	28,3	6,4	22,6	3,8
	F	25,9	3,5	20,6	4,7
	IS	30,0	6,2	21,5	3,8
	MCU	28,03	7,7	23,3	8,1
	UCU	30,8	6,4	25,0	0,9

*BMI: Body mass index (weight (kg)/height²(m)); ¶SD: standard deviation

†Stratum: R=Rural; F=farm; IS= informal settlement; MCU=middle class urban; UCU=upper class urban

Although mean BMI appears to increase from rural to urban strata, there were no significant differences between mean BMI of the strata within age groups and genders ($P < 0,01$). The low mean BMI of the males, particularly in the farm stratum, is notable.

8.2.2 Degree of urbanisation

From the responses to the questions regarding place of birth, it appears that 43% (379) subjects were not born in the area they were living in at the time of the study. Table 8.3 shows the number of subjects, according to gender and age, from each stratum of urbanisation who were born in that specific area and who had not been born there but had moved there from another area.

Table 8.3: Place of birth according to gender, age group and stratum of urbanisation (N=882)

Age group (years)	Rural				Farm				Informal settlement				Middle class urban				Upper class urban				Total			
	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %	¶ S N %	O N %
Females																								
15 - 24,9	13 13,1	17 32,1	6 20,0	5 17,2	12 31,6	5 13,5	17 19,5	1 1,8	21 32,8	13 43,3	69 21,7	39 17,1												
25 - 34,9	19 19,2	9 17,0	5 16,7	10 34,5	8 21,0	15 40,5	24 27,6	26 47,3	16 25,0	6 20,0	72 22,6	75 32,9												
35 - 44,9	21 21,2	11 20,8	7 23,3	7 24,1	11 28,9	7 18,9	22 25,3	8 14,5	19 29,6	7 23,3	80 25,2	47 20,6												
45 - 54,9	24 24,2	7 13,2	9 30,0	4 13,8	5 13,2	5 13,5	13 15,0	15 27,3	6 9,4	3 10,0	57 17,9	44 19,3												
55 - 64,9	22 22,2	9 16,9	3 10,0	3 10,3	2 5,3	5 13,5	11 12,6	5 9,1	2 3,1	1 3,4	40 12,6	23 10,1												
Total	99 65,0	53 35,0	30 51,0	29 49,0	38 51,0	37 49,0	87 61,0	55 39,0	64 68,0	30 32,0	318 58,0	228 42,0												
Males																								
15 - 24,9	18 34,6	9 37,4	12 27,3	4 16,7	6 28,6	8 40,0	11 30,6	7 20,6	13 43,4	22 44,9	60 32,8	50 33,1												
25 - 34,9	10 19,2	1 4,2	9 20,4	5 20,8	4 19,0	3 15,0	8 22,2	9 26,4	6 20,0	14 28,6	37 20,2	32 21,2												
35 - 44,9	12 23,1	2 8,4	5 11,4	6 25,0	6 28,6	0 0	4 11,1	7 20,6	7 23,3	8 16,3	34 18,6	23 12,6												
45 - 54,9	4 7,7	6 25,0	15 34,1	4 16,7	3 14,3	5 25,0	8 22,2	7 20,6	3 10,0	4 8,2	33 18,0	26 14,2												
55 - 64,9	8 15,4	6 25,0	3 6,8	5 20,8	2 9,5	4 20,0	5 13,9	4 11,8	1 3,3	1 2,0	19 10,4	20 10,9												
Total	52 68,0	24 32,0	44 65,0	24 35,0	21 51,0	20 49,0	36 51,0	34 49,0	30 38,0	49 52,0	183 55,0	151 45,0												
TOTAL	151 66,0	77 44,0	74 58,0	53 42,0	59 51,0	57 49,0	123 58,0	89 42,0	94 54,0	79 46,0	501 57,0	379 43,0												

¶S: born in the same area; O: born in other areas

Since the numbers in some cells were small (less than 5), the age groups younger than 35 years were combined for comparison using Chi² with the combined age groups older than 35 years. No significant associations were found between place of birth and age either among the males or the females (P>0,05). By contrast, there was a significant association between place of birth and stratum (P<0,05). There were no associations among strata with place of birth for the females, but among the males, the percentage of subjects who had been born in and still lived in rural areas was significantly higher than the percentage born and living in both middle class (P<0,05; 95% CI= 0,013 to 0,327) and upper class (P<0,001; 95% CI=0,155 to 0,454) urban areas. The percentage of male farm workers who had been born on farms was also significantly higher than the proportion of males who had been born in the upper class urban stratum (P<0,001; 95% CI=0,111 to 0,423).

To determine the percentage of recent arrivals in each stratum, subjects who were not born in their present area of residence, were asked how long they had been living in the present area (Table 8.4). The places of birth were further broken down to determine the percentages of subjects born in different areas but in the same stratum of urbanisation as that in which they were living at the time of the study (Table 8.4)

Table 8.4: Length of time lived in present area according to age group and stratum of urbanisation (N=379)

	Length of time lived in present area (years)													
Stratum of urbanisation	< 1		1 - 5		6 - 10		11 - 15		16 - 20		>20		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Rural	6	19,3	20	18,0	12	14,8	12	21,1	12	26,1	15	27,8	77	20,3
Farm	7	22,6	11	9,9	9	11,1	8	14,0	9	19,6	10	18,5	54	14,2
Informal settlement	2	6,5	18	16,2	23	28,4	5	8,8	1	2,2	8	14,8	57	15,0
Middle class urban	7	22,6	22	19,8	22	27,2	15	26,3	13	28,3	11	20,4	90	23,7
Upper class urban	9	29,0	40	36,0	15	18,5	17	29,8	11	23,9	9	18,5	101	26,6
Total	31	100	111	100	81	100	57	100	37	100	53	100	379	100

From Table 8.4, there appears to be a difference in the trend of time lived in the present area between the rural and farm workers strata and the urban strata (P<0,05). There were no significant differences

between the percentages of subjects who had lived in the rural and farm strata for less than 10 years and for more than 10 years ($P>0,05$). In the informal settlement stratum the percentage of subjects who had lived in that specific area for less than 10 years (75,4%) was significantly higher than the percentage who had lived in the area for more than 10 years (24,6) ($P<0,0001$; 95% CI=0,622 to 0,858). This finding might be expected as informal settlements are fairly recent developments which have shown rapid growth in the past 10 years. Although the percentage of subjects in the upper class urban stratum who had moved there within the past 10 years (63,4%) was significantly higher than that of subjects, who had been in that area for longer than 10 years (36,6%) ($P<0,001$; 95% CI: 0,54 to 0,73), the difference in these percentages (57% and 43% respectively) was not significant for the middle class urban stratum ($P>0,05$; 95% CI=0,458 to 0,671). This does not only mean that there is movement into the upper class stratum from other strata, but also that there is movement among areas within the upper class stratum. From Table 8.5, it can be seen that 66% of the subjects not born in the upper class urban stratum, had moved there from other urban areas.

Table 8.5: Previous stratum of urbanisation (N=379)

Previous stratum of urbanisation	*Present stratum of urbanisation									
	* R		F		IS		MCU		UCU	
	N	%	N	%	N	%	N	%	N	%
Rural	28	36	5	9	7	12	14	15	18	17
Farms- white owned	12	16	43	80	25	44	7	8	2	2
Farm-African owned	6	8	2	4	1	2	6	7	9	9
Informal settlement	0	0	0	0	17	30	1	1	0	0
Urban	22	29	2	4	2	4	60	65	68	66
**Missing	9	12	2	4	5	9	3	3	4	6
Total	77	100	54	100	57	100	91	100	101	100

*Strata of urbanisation: R: rural; F: Farm; IS: Informal settlement; MCU: Middle class urban; UCU: Upper class urban

**Question not answered

Table 8.5 illustrates the movement of subjects across strata of urbanisation, both from less urbanised to more urbanised areas and from more urbanised to less urbanised areas. The farm stratum appears to be the most stable of the strata. Although 42% of the subjects on the farms had not been born on the farm they were living on at the time of the study, 84% of these subjects had moved there from another white owned farm. Thus, they had moved within a very similar level of urbanisation. Within the rural stratum, just over third of the subjects (36%) had moved within the stratum from another rural area, while

24% had moved to the rural area from farms, thus moving across strata. However, just less than a third (30%) of subjects had previously lived in urban areas, and could be thought of as having moved from a more urbanised to a less urbanised stratum. The greatest movement into the informal settlements was from the farm and rural areas (58%) while 30% of subjects had moved within the stratum. In the middle and upper class strata, there is more movement within the strata than across strata. Approximately a third of the subjects had moved into the urban areas from the rural and farm strata, while 66% had previously lived in the same strata in another area.

In addition to movement across strata by way of changing areas of residence, there is also considerable contact among strata of urbanisation due to visiting of relatives and friends in other strata. Of the subjects in the rural and farm strata, 77% (275) had relatives living in urban areas whom they visited. The majority (63%) had visited relatives in urban areas within the previous year, while 19% had visited urban areas in the past two years. Generally visits were undertaken once to three times per year (70% of subjects). Several subjects visited urban areas once every two months or more frequently. Although 58% (309) subjects in urban areas knew of relatives in rural and farm areas, 16% (50) had never visited or had last visited these relatives more than five years previously. As with the rural and farm strata subjects, most of the remaining 259 subjects had visited in the previous 12 months (60%) and most (68%) visited at least one to three times per year.

8.2.3 Meal patterns

The responses to the questions regarding the number of meals eaten per day showed that by far the majority of subjects (649, 73%) across all strata ate three meals per day, in comparison to 21,5% (191) subjects who ate two meals per day. Only 25 subjects (3%) usually had one meal a day and the same number had more than three meals a day. The number of meals eaten per day for the various strata of urbanisation is given in Table 8.6.

Table 8.6: Number of meals eaten per day across strata of urbanisation (N=890)

Number of meals per day	*Stratum of urbanisation											
	*R		F		IS		MCU		UCU		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
1	7	3,0	3	2,3	5	2,4	5	2,5	5	2,5	25	2,8
2	60	26,0	25	19,5	27	23,0	49	23,0	30	15,3	191	21,5
3	148	64,1	100	78,1	86	73,2	156	73,0	159	80,7	649	72,9
4	16	6,9	0	0	3	2,5	3	1,4	3	1,5	25	2,8
Total	231	100,0	128	100	121	100,0	213	100,0	197	100,0	890	100

*Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

The percentage of subjects who ate three meals per day was significantly lower in the rural stratum than the percentages in the other four strata ($P<0,05$). However, when the percentage of subjects who ate four meals was included, the differences between strata were no longer significant ($P>0,05$). Table 8.7 sets out the time when and the place where meals were usually eaten. To simplify the analysis of the results, subjects who ate one or two meals per day were added into the appropriate time with the subjects eating three meals per day.

Table 8.7 Time and place of meals (N=890)

Time and place of meals	Stratum of urbanisation						
	R N %	F N %	IS N %	MCU N %	UCU N %	Total N %	
First meal of the day							
Time							
Before 0700	20 9,2	6 4,8	5 4,6	12 6,3	24 13,4	67 7,5	
0700-0900	57 26,2	36 28,8	37 34,3	74 38,7	64 35,7	268 30,1	
0900-1100	125 57,3	74 59,2	57 52,8	102 53,0	79 44,1	437 49,0	
After 1100	16 7,3	4 3,2	11 10,2	10 5,2	12 6,8	53 5,9	
Place							
Home	195 89,4	74 59,0	85 78,7	159 83,0	95 53,0	608 68,3	
Work	23 10,6	51 41,0	23 21,3	35 17,0	84 47,0	216 24,3	
Second meal of the day							
Time							
Before 1200	25 13,4	9 8,3	11 11,1	11 5,6	30 16,7	86 9,7	
1200-1300	17 9,1	10 9,3	16 16,1	52 26,3	25 13,9	120 13,5	
1300-1400	103 55,1	73 67,6	45 45,5	83 41,9	67 37,2	371 41,7	
After 1400	42 22,4	16 14,8	27 27,3	52 26,3	58 32,2	195 21,9	

Time and place of meals	Stratum of urbanisation						
	R N %	F N %	IS N %	MCU N %	UCU N %	Total N %	
Place							
Home	146 77,2	57 52,3	78 78,8	134 67,7	86 47,8	501 56,3	
Work	41 22,8	51 47,7	21 21,2	64 32,3	94 52,2	271 30,4	
Third meal of the day							
Time							
Before 1800	29 13,8	5 4,2	4 4,0	6 3,2	5 2,8	49 5,5	
1800-1900	35 16,7	22 18,3	7 7,0	18 9,6	22 11,9	104 11,7	
1900-2000	91 43,3	54 45,0	48 48,0	78 41,7	74 40,2	345 38,9	
After 2000	55 26,2	39 32,5	41 41,0	85 45,5	83 45,1	303 34,0	
Place							
Home	203	117	98	176	173	767 86,1	
Work	7	3	0	3	11	24 2,7	

Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

Although three meals a day were the norm across all strata of urbanisation (Table 8.6), there was considerable variation among strata regarding the time and place of meals (Table 8.7). Possibly, the differences are due, more to the sample selected, than to the stratum of urbanisation. In the rural, informal settlement and, in some cases, the middle class urban strata data collection centres were at clinics, thus drawing people who would be at home during the day such as house wives or the unemployed. This is reflected in the timing of the meals, especially of the first meal of the day ('breakfast'). The majority of subjects in these strata ate breakfast between 0900 and 1100 (53 to 57%) and by far the majority ate their first meal at home (79% to 89%). Most of the subjects in all strata (64% rural, 76% farm, 67% informal settlement and 68% middle class urban) except the upper class urban stratum (51%) ate the second meal between 1200 and 1400, the typical 'lunch time'. The difference in the upper class urban stratum where 32% of subjects ate after 1400 could be explained by the fact that many of the subjects were scholars or teachers and may have eaten once they got home after the school day (usually after 1400). In the farm worker stratum, the meal times appear very consistent, due to the following of a set routine. Farm workers start work early in the morning and are given a break at approximately 0900 when they eat breakfast. The time of the midday meal is also set, so that 68% of the subjects ate lunch between 1300 and 1400. The women on the farms tended to follow very similar patterns to the males. In the upper class urban stratum, subjects were recruited at places of employment such as schools, hospitals, the University of North West and the Department of Health.

The snacking patterns of the subjects are given in Table 8.8. Of note is the high consumption of tea as a beverage between meals, especially during the morning. In the afternoon, carbonated drinks and fruit juices replaced tea to some extent.

[illegible]

Time and type of snack	Stratum of urbanisation									
	R N=231		F N=128		IS N=121		MCU N=213		UCU N=197	
	N	%	N	%	N	%	N	%	N	%
Tea	38	34,2	21	51,2	17	48,5	30	35,7	25	20,8
Coffee	2	1,8	1	2,4	0		2	2,4	0	
*Cold drinks	63	56,7	16	39,0	17	48,5	43	51,2	91	75,8
Milk	4	3,6	1	2,4	0		0		2	1,7
**Alcoholic beverages	1	0,9	0		0		3	3,6	2	1,7
†Snacks	3	2,7	1	2,4	0		4	4,8	0	
Fruit	0	0	1	2,4	1	2,5	2	2,4	0	
Total % Sample	111 48,1		41 32,0		35 29,0		84 39,0		120 61,0	
Evening (N= 376; % total sample: 42,2)										
Tea	51	67,0	59	86,8	29	72,5	70	67,9	49	44,1
Coffee	1	1,0	7	10,3	3	7,5	11	10,7	0	
*Cold drinks	17	22,3	1	1,5	7	17,5	18	17,5	33	29,7
Milk	3	3,9	1	1,5	0		1	1,0	3	2,7
**Alcoholic beverages	2	2,6	0		1	2,5	3	3,0	1	0,9
† Snacks	2	2,6	0		0		0		3	2,7
Total % Sample	76 32,9		68 53,0		40 33,0		103 48,0		89 45,2	

%; percentage of subjects consuming snacks;

*Cold drinks include carbonated beverages and fruit juice; **alcoholic beverages include commercial beer, homemade beer and sorghum beer ('Tlokwe'); † snacks include savouries such as potato crisps and peanuts and sweet snacks such as cookies, sweets and chocolates; Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

There were no significant differences in the proportions of subjects from the strata of urbanisation who consumed snacks during the morning ($P>0,05$). However, there were marked differences for the consumption of snacks during the afternoon and evening. During the afternoon, the rural and upper class subjects showed the highest percentages of snack consumption (48% and 61% respectively). The percentage consumption in the rural stratum was significantly higher than the farm, informal settlement and middle class urban strata ($P<0,05$), while that of the upper class urban stratum was significantly higher than all the other strata ($P<0,01$). During the evening, the highest consumption of snacks

occurred in the farm (53%), middle class urban (48%) and upper class urban (45%) strata and the lowest in the rural and informal settlement strata (33% each). The differences in percentages between the rural and informal settlement strata on the one hand and the farm, middle class urban and upper class urban strata on the other were significant ($P < 0.05$)

8.2.4 Energy and macronutrient intakes

The mean reported energy and macronutrient intakes of the females are given in Table 8.9 and for the males in Table 8.10. In order to show the effects of constant and proportional bias, as described in Chapter 7, on the dietary intakes of the entire sample, the log (base e) of the individual intakes of those nutrients tested (total energy, total protein and total fat, calcium, iron, vitamin A and vitamin C) were substituted into the formula $Q' = (Q - \alpha_Q) / \beta_Q$ using the values for α_Q and β_Q derived from the modified method of Kaaks *et al.* (1994b) (7.33; Tables 7.21 and 7.22). The results were then converted back to natural numbers, and the means and standard deviations of these adjusted intakes calculated. The adjusted mean intakes are given below the reported mean intakes for comparison.

The Recommended Dietary Allowances (RDA) (Food and Nutrition Board, 1989) are also shown for comparison. The prudent diet recommendations are shown for those nutrients for which there is no RDA (cholesterol and fibre) (American Heart Association, 1986).

Table 8.9: Females: Mean and standard deviation of reported energy and macronutrient intakes (N=552)

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	§RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group: 15 to 24,9 years (N=108)												
		N=30		N=11		N=17		N=18		N=32		N=108		
Energy (kJ)	9240	8925	1703	6914	1600	7917	2013	8918	3330	8513	2477	8434	2363	
Adjusted energy (kJ)		9336	2942	6212	2313	7831	3416	9912	6153	8943	4191	8760	4102	
Total protein (g)	46	65,8	13,6	57,2	15,2	57,8	15,8	69,2	23,2	66,7	20,8	64,5	18,4	
Adjusted protein (g)		67,9	24,8	54,5	25,6	55,7	25,7	77,7	44,3	72,3	39,4	67,6	33,9	
Plant protein (g)		35,4a	9,5	25,2	9,6	27,8	8,2	31,3	13,9	25,3a	7,9	29,5	10,5	a*
Animal protein (g)		30,2a	11,2	31,9	11,8	29,9	12,0	37,7	15,7	41,2a	15,2	34,8	14,1	a*
Total fat (g)		59,8	20,6	53,1	23,2	64,9	24,0	74,8	30,3	76,1	24,6	67,3	25,4	
Adjusted fat (g)		60,1	47,9	50,2	42,9	73,6	58,2	102,2	82,2	100,4	67,8	72,8	64,2	
¶Cholesterol (mg)	300	283,6	137,1	275,2	153,1	294,1	216,2	302,7	155,1	332,3	164,4	302,2	162,7	
¶P:S ratio	1	0,76	0,33	0,56	0,21	0,77	0,2	0,75	0,20	0,67	0,22	0,71	0,25	
Total carbohydrate (g)		334,1	91,2	240,3	61,6	272,5	71,1	296,9	125,8	271,5	87,6	289,7	95,1	
¶Fibre (g)	30	18,9	7,5	11,9	4,4	16,0	5,7	20,2	10,4	16,0	5,8	17,1	7,4	
Alcohol (g)		1,9	8,5	0,03	0,09	0,2	0,8	0	0	0,11	0,34	0,59	4,5	

Nutrlent		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entlire sample		P-value
	§RDA	Mean	†SD	Mean	+SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group 25 to 34,9 years (N=151)												
		N=28		N=15		N=27		N=50		N=31		N=151		
Energy (kJ)	9240	7917	2766	8762	2290	8732	3328	8819	2792	8791	2938	8634	2859	
Adjusted energy (kJ)		7941	4555	9292	3984	9619	5783	9562	5005	9563	5228	9245	5006	
Total protein (g)	50	59,38	19,8	65,66	16,5	62,8	24,3	69,4	19,9	70,5	22,1	66,3	21,1	
Adjusted protein (g)		59,6	33,6	69,0	29,2	67,1	44,2	76,8	36,8	79,5	46,1	71,7	39,3	
Plant protein (g)		32,6	13,7	35,4a	11,6	32,1b	13,4	30,8	11,0	27,7ab	8,9	31,2	11,7	a**;b*
Animal protein (g)		26,8	12,5	30,1a	10,7	30,5	14,8	38,4	15,8	42,7a	17,8	35,0	16,0	a*
Total fat (g)		50,6	20,1	53,8	25,2	58,4	30,0	67,6	26,3	73,0	30,0	62,7	27,6	
Adjusted fat (g)		45,0	27,3	53,3	35,2	66,7	39,3	81,8	40,6	100,0	68,32	72,8	71,3	
¶Cholesterol (mg)	300	250,5	170,0	224,5	150,2	251,7	158,8	336,5	186,9	318,4	148,8	291,1	171,4	
¶P:S ratio	1	0,89a	0,34	0,76	0,35	0,83	0,21	0,80	0,29	0,63a	0,26	0,78	0,31	a**
Total carbohydrate(g)		301,6	117,6	328,1	97,1	332,0	130,5	301,8	107,3	288,5	104,8	307,1	111,8	
¶Fibre (g)	30	16,7	7,2	15,5	5,5	17,7	7,1	19,0	7,0	18,6	7,5	17,0	7,0	
Alcohol (g)		1,45	4,3	7,8	15,1	0,9	2,3	3,9	10,7	2,0	6,3	2,9	8,6	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	§RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group: 35 to 44,9 years (N=127)												
		N=32		N=14		N=18		N=30		N=33		N=127		
Energy (kJ)	9240	7378	2727	7527	3236	7129	2283	7816	2136	8092	2945	7652	2641	
Adjusted energy (kJ)		7626	5018	7613	5559	6701	3650	7713	3571	8416	5036	7719	4565	
Total protein (g)	50	52,3	16,0	57,2a	26,2	58,2	21,9	62,5	17,4	71,2a	23,2	61,2	21,4	a**
Adjusted protein (g)		50,0	26,9	58,7	44,9	58,5	38,1	63,9	30,2	81,4	45,6	63,6	57,5	
Plant protein (g)		30,0	12,9	28,6	13,1	23,6	8,8	27,8	8,8	25,1	11,1	27,1	11,4	
Animal protein (g)		22,2	9,9	28,6	16,9	34,5	20,1	34,6	14,5	46,0	16,8	34,0	17,5	
Total fat (g)		44,9	18,4	47,7	21,9	51,0	23,4	62,2	19,4	68,6	26,5	56,5	23,8	
Adjusted fat (g)		58,6	27,3	21,6	35,2	71,8	39,3	37,7	40,6	90,0	68,3	57,5	49,0	
¶Cholesterol (mg)	300	236,7	170,2	201,1	163,7	327,6	253,3	298,3	198,6	374,2	177,4	296,9	198,3	
¶P:S ratio	1	0,91a	0,37	0,68	0,27	0,79	0,34	0,74	0,27	0,64a	0,20	0,76	0,31	a**
Total carbohydrate(g)		290,3	135,8	280,8	136,3	234,4	99,6	261,3	94,4	253,1	110,9	264,4	115,0	
¶Fibre (g)	30	16,1	8,0	12,8	6,2	12,6	5,6	16,8	6,7	17,9	7,2	15,8	7,2	
Alcohol (g)		1,1	5,1	5,2	10,5	10,6	32,5	2,8	10,1	2,4	8,7	3,6	14,6	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	§RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group: 45 to 54,9 years (N=102)												
		N=32		N=13		N=10		N=28		N=19		N=102		
Energy (kJ)	9240	8756	2585	6618	3356	7960	3504	7003	2134	8153	2972	7803	2820	
Adjusted energy (kJ)		9384	4319	6361	4974	8376	6046	6480	3362	8498	5460	7938	4681	
Total protein (g)	50	67,9	21,6	47,9	25,6	63,3	26,9	55,5	15,8	69,6	24,2	61,8	22,6	
Adjusted protein (g)		74,7	39,0	45,0	37,7	68,8	48,0	52,3	25,0	78,6	47,7	64,9	39,2	
Plant protein (g)		35,2	11,5	25,4	16,0	26,7	10,1	27,2	12,1	26,5	15,3	29,2	13,3	
Animal protein (g)		32,6	15,8	22,5a	14,0	36,6	21,6	28,3b	10,6	42,9ab	13,5	32,4	15,6	a**,b*
Total fat (g)		56,9a	23,9	32,9	20,8	60,6	31,9	48,5b	14,2	70,1ab	29,0	54,3	25,4	a***,b*
Adjusted fat (g)		58,6	47,9	21,6	42,9	71,8	58,2	37,7	82,2	90,0	67,8	55,3	58,0	
¶Cholesterol (mg)	300	285,5	185,4	137,2	83,0	394,4	247,9	268,6	151,8	313,5	149,6	277,8	176,4	
¶P:S ratio	1	0,85a	0,32	0,66	0,27	0,80	0,20	0,8	0,27	0,55a	0,16	0,75	0,28	a**
Total carbohydrate(g)		320,6	108,9	270,9	138,0	255,0	107,9	250,6	92,6	259,6	99,6	276,8	108,1	
¶Fibre (g)	30	18,8	7,4	10,9	6,7	16,2	4,3	15,9	6,9	19,3	11,1	16,8	8,1	
Alcohol (g)		6,0	13,7	4,7	13,8	10,9	15,4	3,3	7,7	0,3	0,57	4,5	11,2	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	§RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group: 55 to 64,9 years (N=63)												
		N=30		N=6		N=8		N=16		N=3		N=63		
Energy (kJ)	7980	7371	2576	7199	2213	8374	2854	6341	2195	10954	1255	7391	2581	
Adjusted energy (kJ)		7090	4030	6757	3139	8805	4438	5561	3096	13082	2430	7172	3982	
Total protein (g)	50	58,5	20,1	58,7	18,9	62,4	23,4	49,4	13,8	84,8	5,5	58,0	19,6	
Adjusted protein (g)		58,6	31,5	57,7	30,8	65,5	41,6	42,5	19,0	103,6	11,6	57,5	31,6	
Plant protein (g)		28,8	12,8	26,1	12,8	34,7	13,3	23,6	10,0	36,1	4,1	28,3	12,2	
Animal protein (g)		29,8	14,1	32,5	13,2	27,6	13,9	25,7	9,8	48,5	9,4	29,6	13,3	
Total fat (g)		49,6	21,3	44,0a	14,4	54,1b	19,9	44,5c	14,2	94,2abc	17,9	50,5	21,0	a,b,c*
Adjusted fat (g)		44,1	48,0	30,9	42,9	49,4	58,2	31,8	82,2	144,8	67,8	45,2	42,3	
¶Cholesterol (mg)	300	305,1	145,0	215,3	114,2	206,8	114,2	224,3	140,7	413,7	53,9	268,7	142,0	
¶P:S ratio	1	0,85	0,35	0,46	0,11	0,76	0,21	0,84	0,41	0,8	0,43	0,80	0,35	
Total carbohydrate (g)		265,4	105,1	273,8	108,7	306,1	124,9	232,3	98,5	354,3	61,1	267,2	106,0	
¶Fibre (g)	30	16,5	6,7	11,7	4,2	17,0	5,5	12,9	5,3	24,2	2,7	15,6	6,4	
Alcohol (g)		3,0	9,2	2,6	3,8	7,9	20,1	0,1	0,4	1,6	2,7	2,8	2,7	

*P<0,05; **P<0,01; ***P<0,001; §RDA: Recommended dietary allowance; ¶ Prudent diet recommendations (AHA, 1986; Trusswell, 1987); † Standard deviation; a,b,c: strata for which mean intakes differ significantly
 Stratum of urbanisation: R: rural, F: farm workers; IS: informal settlement; MCU: middle class urban; UCU: upper class urban

Table 8.10: Males: mean and standard deviation of reported energy and macronutrient intakes (N=338)

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
		Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
§RDA		Age group: 15 to 24,9 years (N=110)												
		N=27		N=16		N=14		N=18		N=35		N=100		
Energy (kJ)	12600	9379	2998	7361	2855	8589	3227	10991	3201	10100	3500	9478	3346	
Adjusted energy (kJ)		10601	5494	7229	4683	9304	5818	13681	6245	12109	6667	10929	6187	
Total protein (g)	59	76,5	26,0	58,9	23,6	69,8	25,5	88,3	23,4	80,2	28,8	76,2	27,2	
Adjusted protein (g)		92,6	54,2	60,3	41,4	79,4	51,0	115,0	51,9	101,2	61,9	92,6	56,1	
Plant protein (g)		38,8	17,1	27,7	10,6	30,8	12,2	38,2	15,8	35,8	12,7	35,1	14,4	
Animal protein (g)		37,6	15,0	31,1	15,9	38,8	17,5	49,8	12,6	44,3	22,4	41,0	18,4	
Total fat (g)		66,1	17,6	49,0ab	20,5	66,0	31,4	87,4a	27,9	82,4b	33,8	72,3	29,9	a,b**
Adjusted fat (g)		71,8	38,8	41,9	32,1	82,9	93,4	134,1	91,6	127,0	117,2	96,6	90,9	
¶Cholesterol (mg)	300	354,9	140,3	262,4	206,5	390,9	232,6	515,9	268,6	430,7	308,8	397,5	252,6	
¶P:S ratio	1	0.83	0,21	0,77	0,38	0,81	0,36	0,71	0,14	0,72	0,72	0,77	0,28	
Total carbohydrate(g)		335,6	130,2	271,3	121,6	289,2	121,6	364,5	124,1	335,9	121,9	325,1	125,7	
¶Fibre (g)	30	23,5a	11,8	12,6abc	4,8	14,2	6,9	23,4b	18,5	21,9c	3,8	20,4	9,9	a,b,c*
Alcohol (g)		2,1	3,6	2,3	5,8	5,3	7,9	6,5	19,2	3,5	6,3	3,1	9,9	

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
		Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
	§RDA	Age group 25 to 34,9 years (N=70)												
		N=11		N=15		N=7		N=17		N=20		N=70		
Energy (kJ)	12180	7634	2923	8270	3564	10479	2443	9507	2220	8745	2198	9112	2766	
Adjusted energy (kJ)		7667	4446	8933	6033	12400	4900	10569	4198	11002	4079	10069	4803	
Total protein (g)	63	63,6	26,6	64,5	24,7	78,7	29,3	76,7	20,2	78,0	16,8	72,6	22,7	
Adjusted protein (g)		69,2	45,9	70,1	44,0	97,5	63,5	90,6	37,8	91,9	32,4	83,6	70,4	
Plant protein (g)		29,5	14,9	33,3	15,6	35,1	15,7	34,5	13,7	29,8	9,8	32,2	13,4	
Animal protein (g)		33,9	19,2	31,2	13,6	43,5	18,5	41,9	18,7	48,1	15,9	40,3	17,8	
Total fat (g)		54,1	22,4	48,0a	20,7	81,6	38,9	74,1	20,3	78,9a	29,0	67,5	28,2	a*
Adjusted fat (g)		51,2	37,5	40,6	34,8	127,9	115,1	91,5	45,8	111,5	82,1	83,6	70,4	
¶Cholesterol (mg)	300	356,1	203,3	258,7	102,6	435,3	197,3	354,7	205,5	365,4	175,9	345,5	192,5	
¶P:S ratio	1	0,89	0,36	0,69	0,37	0,67	0,21	0,85	0,32	0,63	0,20	0,74	0,31	
Total carbohydrate(g)		264,0	106,4	304,5	149,7	328,0	91,4	305,5	106,4	289,6	83,6	296,5	108,5	
¶Fibre (g)	30	15,7	9,3	14,5	7,1	18,9	9,5	17,1	6,2	18,1	6,9	16,8	7,4	
Alcohol (g)		5,1	9,8	12,7	16,6	21,9	28,5	12,8	18,9	21,2	21,7	14,9	19,7	

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
		Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
	§RDA	Age group: 35 to 44,9 years (N=58)												
		N=15		N=11		N=6		N=11		N=15		N=58		
Energy (kJ)	12180	10377	3191	8727	2604	8769	3592	10524	2198	8794	2712	9516	2861	
Adjusted energy (kJ)		12486	5962	9316	4443	9673	6589	12445	93,3	9472	4801	10807	5221	
Total protein (g)	63	76,4	25,1	61,6	17,5	67,1	18,2	77,6	23,5	72,5	23,2	71,8	22,4	
Adjusted protein (g)		91,8	49,9	62,2	30,3	71,6	32,5	93,3	51,9	83,5	46,6	74,2	67,1	
Plant protein (g)		41,3	16,1	37,8a	16,6	27,4	16,0	33,6	9,8	27,0a	9,0	34,0	14,3	a*
Animal protein (g)		35,1	17,2	23,7a	14,0	39,4	23,4	43,8	21,6	45,4a	16,0	37,7	19,0	a*
Total fat (g)		58,6	18,9	37,5	19,9	63,3	22,7	79,5	28,5	75,5	27,7	63,4	27,5	
Adjusted fat (g)		57,3	35,0	26,0	28,9	68,1	48,1	112,0	88,2	101,4	77,9	9525	5156	
¶Cholesterol (mg)	300	275,1	116,8	197,1a	173,6	400,0	212,6	382,8	165,4	452,1a	218,3	339,4	195,4	a*
¶P:S ratio	1	0,93	0,53	0,79	0,51	0,89	0,51	0,85	0,47	0,61	0,16	0,8	0,45	
Total carbohydrate(g)		376,2	140,1	361,8	147,4	240,9	112,7	333,7	103,2	261,7	77,6	321,8	125,9	
¶Fibre (g)	30	21,3	9,8	14,9	5,9	13,0	4,9	17,1	5,4	15,7	6,8	17,0	7,5	
Alcohol (g)		20,6	30,2	12,2	11,3	38,4	53,1	24,7	18,9	12,2	16,4	19,5	26,3	

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
		Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
	§RDA	Age group: 45 to 54,9 years (N=61)												
		N=11		N=19		N=8		N=16		N=7		N=61		
Energy (kJ)	12180	8962	3204	9303	3144	7252	2627	9007	2300	8329	3268	8777	2882	
Adjusted energy (kJ)		9860	5620	10500	6045	6966	47,7	9713	66,9	8855	87,5	9525	5157	
Total protein (g)	63	70,2	27,4	66,7	24,5	52,1	18,3	64,3	17,4	73,6	28,4	65,6	23,2	
Adjusted protein (g)		81,0	53,7	73,8	45,3	47,7	27,1	66,9	33,4	87,5	55,4	71,5	43,5	
Plant protein (g)		32,4	13,0	35,8	18,2	26,8	9,6	35,6	9,7	26,8	12,5	32,9	13,8	
Animal protein (g)		37,8	20,2	30,9	12,9	25,3	12,1	28,6	13,7	46,9	20,1	32,6	16,2	
Total fat (g)		61,5	27,4	45,1	17,4	42,9	17,8	55,4	22,2	71,5	24,3	53,5	22,9	
Adjusted fat (g)		69,2	59,0	34,4	26,6	31,3	25,0	53,8	50,3	87,6	58,6	51,5	46,9	
¶Cholesterol (mg)	300	366,2	204,2	258,7	214,6	260,0	238,6	237,1	136,0	489,1	207,6	290,0	207,7	
¶P:S ratio	1	0,86	0,38	0,55a	0,23	0,70	0,22	0,94a	0,39	0,82	0,25	0,76	0,34	a**
Total carbohydrate(g)		300,2	104,8	365,5	131,8	252,6	93,8	328,8	91,5	250,2	116,4	316,1	116,0	
¶Fibre (g)	30	17,6	8,9	14,2	6,7	12,8	3,9	18,1	5,6	16,5	6,4	15,9	6,7	
Alcohol (g)		15,5	24,5	16,4	26,8	20,0	23,6	13,9	16,3	7,1	9,9	15,0	21,6	

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
		Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
	§RDA	Age group: 55 to 64,9 years (N=39)												
		N=14		N=8		N=6		N=9		N=2		N=39		
Energy (kJ)	9660	8649	3254	7617	2668	8271	4622	9366	3426	8055	2984	8510	3290	
Adjusted energy (kJ)		9085	5142	7529	4274	9324	8056	10693	6150	8098	4804	9123	5541	
Total protein (g)	63	69,6	30,6	57,0	21,7	65,5	33,4	68,0	26,9	69,1	16,6	65,9	27,1	
Adjusted protein (g)		78,6	51,8	56,2	37,6	75,2	61,3	76,8	49,9	73,9	30,1	72,8	48,0	
Plant protein (g)		37,3	15,1	30,7	13,2	33,3	24,4	34,2	14,1	29,2	14,1	34,1	15,6	
Animal protein (g)		32,2	20,6	26,3	9,9	31,9	12,7	33,8	17,2	39,9	2,5	31,7	15,9	
Total fat (g)		53,0	26,0	37,6	15,6	49,3	20,0	61,1	37,7	66,2	19,9	51,8	26,8	
Adjusted fat (g)		50,2	40,3	23,6	23,9	41,2	28,2	79,0	86,7	69,9	42,5	51,0	52,7	
¶Cholesterol (mg)	300	306,3	189,0	164,9	38,1	351,5	330,2	341,0	225,0	386,5	208,6	296,1	209,5	
¶P:S ratio	1	0,98	0,42	0,63	0,28	0,99	0,46	0,74	0,18	0,61	0,08	0,84	0,37	
Total carbohydrate(g)		323,4	120,2	294,0	110,4	293,9	206,0	314,5	123,9	264,3	127,0	7,4	129,4	
¶Fibre (g)	30	20,5	11,9	14,1	6,5	16,3	10,4	16,0	8,2	21,5	10,6	17,6	9,5	
Alcohol (g)		4,5	7,3	12,9	18,7	15,9	10,0	25,4	59,1	1,8	2,5	12,6	30,0	

*P<0,05;**P<0,01;***P<0,001; §Recommended dietary allowance; ¶ Prudent diet recommendations (American Heart Association, 1986); † Standard deviation; a,b,c : strata for which mean intakes differ significantly; Stratum of urbanisation: R=rural, F=farm; IS=informal settlements, MCU=middle class urban, UCU=upper class urban

From Tables 8.9 and 8.10, it is apparent that most of the significant differences between reported mean intakes in both genders and across all age groups occur between the rural, farm and upper class urban strata. Also, the nutrients showing significant differences are similar among subgroups. No significant differences were found for energy intakes between strata of urbanisation for any age groups for either males or females ($P>0,05$). Apart for the informal settlement and upper class urban female subjects in the 55 to 64,9-year age group, none of the subgroups achieved the RDA for energy. When the energy intakes were adjusted for constant and proportional bias, the means of nine of the female subgroups reached the RDA. For the males, however, even when adjusted for constant and proportional bias only the mean energy intakes of five subgroups achieved the RDA (middle class urban, 15-24 years; informal settlement, 25 to 34,5 years; rural and middle class urban, 35 to 44,9-years and middle class urban, 55 to 64,9 years). Figures 8.1 and 8.2 show the percentages of females and males who reported energy intakes of less than 67% of the RDA.

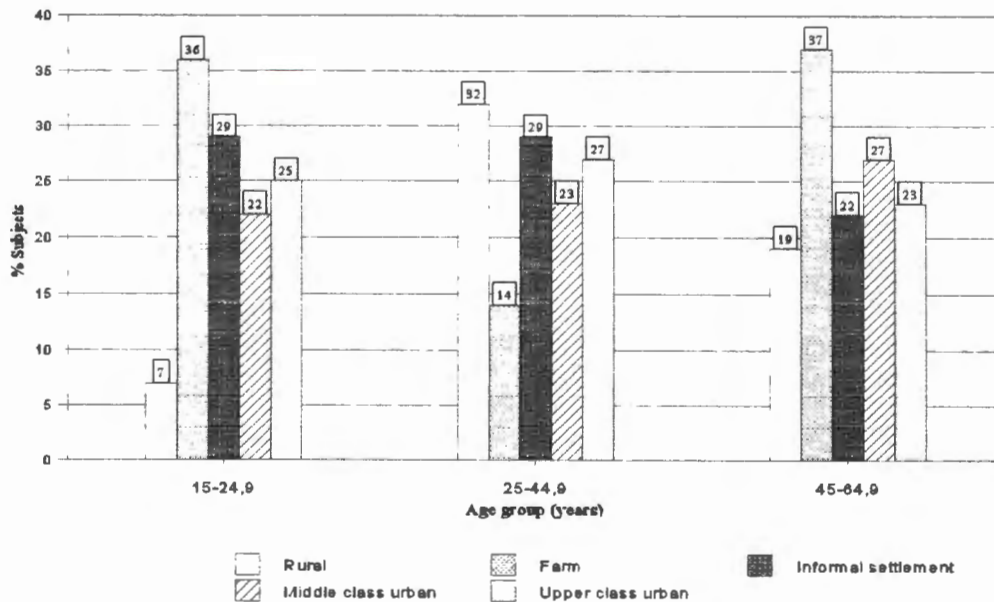


Figure 8.1: Percentage females with energy intakes below 67% RDA according to age group and stratum of urbanisation

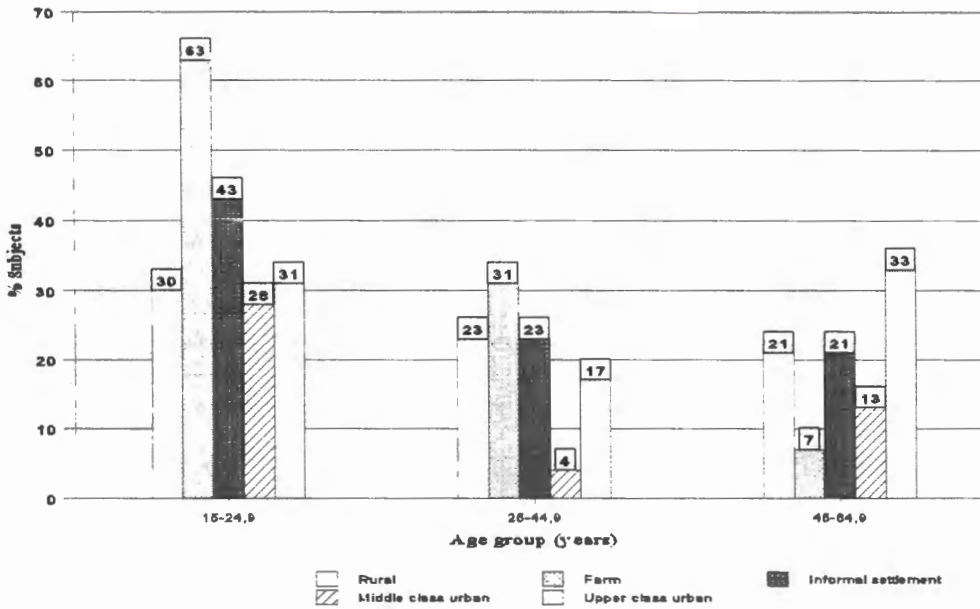


Figure 8.2: Percentage males with energy intakes below 67% RDA according to age group and stratum of urbanisation.

The percentage of subjects with reported energy intakes below 67% RDA varied from 4% (middle class urban males between 25 and 44,9 years of age) to 63% (farm worker males younger than 25 years of age). With the exception of the eldest male age group, the farm stratum showed the highest percentages of subjects with intakes below 67% RDA. Despite the seemingly large differences, no percentage differed significantly from the others within age groups ($P > 0,01$).

For total protein, the only statistically significant difference in mean reported intakes occurred in the 35 to 44,9-year female age group between the upper class urban stratum and the farm stratum ($P < 0,01$). In all but three subgroups, both the mean reported intake and the adjusted intake reached or exceeded the RDA for protein. In the middle class urban female 55 to 64,9-year age group, the actual intake was 49 g compared to the RDA of 50g while the adjusted intake was 7,5g lower than the RDA. For the males, in the farm worker stratum, the actual reported and adjusted mean intakes for the 35 to 44,9-year group were slightly lower than the RDA, while in the age group older than 55 years, the reported mean and adjusted mean intakes were 57 g and 56 g compared to 63 g respectively. The only subgroups in which more than 10% of subjects reported mean total protein intakes below 67% RDA were the 45 to 64,9 -year female age group in the farm stratum (21%), the males younger than 25 years of the farm stratum (19%) and the males in the 45 to 64,9-year age group in the informal settlement stratum (21%).

Although mean reported total protein intakes showed few differences, when plant and animal protein intakes were considered separately, several significant differences occurred. In the female age group of 15 to 24,9 years the mean reported plant protein intake (35,4 g) was significantly higher in the rural stratum than in the upper class urban stratum (25,3 g) ($P<0,05$). Conversely, the mean reported animal protein intake was significantly higher in the upper class urban stratum (41,2 g) than in the rural stratum (30,2 g) ($P<0,05$). Similarly, the plant protein intake of the 25 to 34,9 -year female age group of the farm stratum was significantly higher than the upper class urban stratum ($P<0,001$) while the animal protein intake of the upper class urban stratum in this age group was significantly higher than that of the farm stratum ($P<0,05$). In the males, only the age group of 35 to 44,9 years showed significant differences in reported mean plant and animal protein intakes between the farm and upper class urban strata ($P<0,05$). The percentages of plant and animal protein of total protein of the combined age groups for each stratum are shown in Figure 8.3 for females and Figure 8.4 for males.

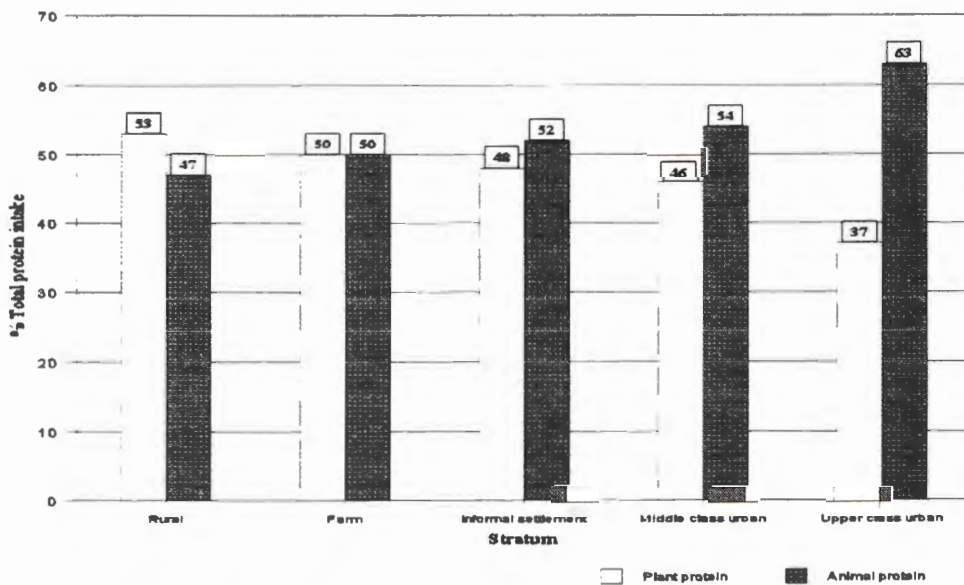


Figure 8.3: Proportion of total protein provided by plant and animal protein of females according to stratum of urbanisation (N=552).

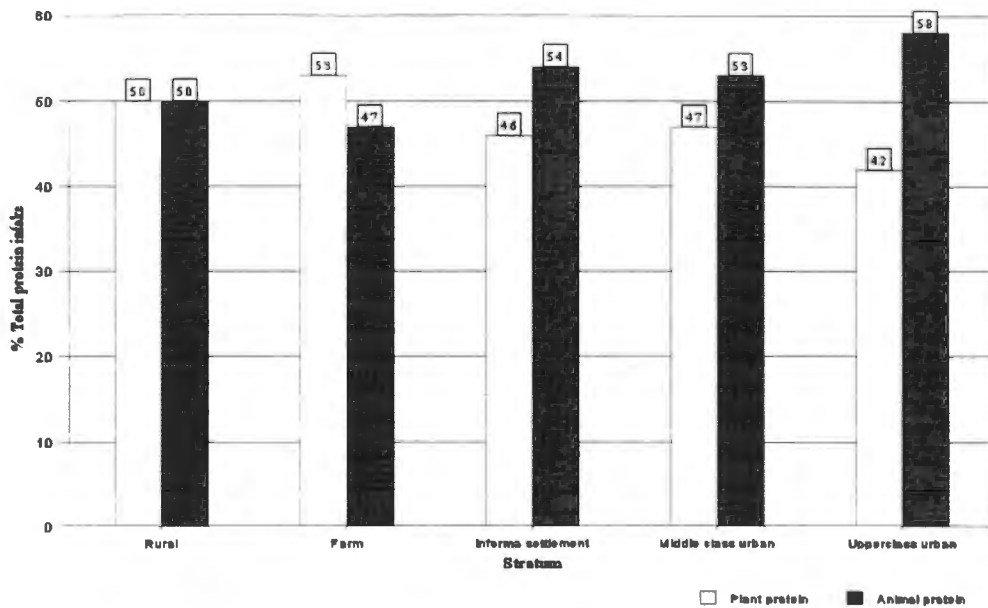


Figure 8.4: Proportion of total protein provided by plant and animal protein for males according to stratum of urbanisation (N=338).

Although there appears to be a definite trend among both the females and the males for the proportion of animal protein to increase from the rural and farm strata to the urban strata, the differences in proportions among strata are not significant ($P>0,05$). Only the difference in proportions between animal and plant protein for the upper class urban stratum is significant for males ($P<0,05$) and females ($P<0,001$).

Mean reported total fat intakes showed significant differences in several subgroups, namely, total fat intake was significantly higher in the upper class urban stratum than the rural stratum ($P<0,001$) and the middle class urban stratum ($P<0,05$) in the female age group of 45 to 54,9 years. Mean reported total fat intake was also significantly higher in the upper class urban stratum than the farm, informal settlement and middle class urban strata in the female age group of 55 to 64,5 years ($P<0,05$). Among the males, significant differences in mean reported total fat intake occurred between the middle and upper class urban strata and the farm stratum in the 15 to 24,9- year age group ($P<0,05$) and between the upper class urban stratum and the farm stratum in the age group of 25 to 34,9 years ($P<0,05$).

Other nutrients which showed significant differences were fibre, where the mean intake reported by the farm stratum males in the youngest age group was significantly lower than that of the males in the rural, middle class urban and upper class urban strata ($P<0,05$), and cholesterol in the male age group

of 35 to 44,9- years where the mean intake of the upper class urban stratum was significantly higher than that of the farm stratum ($P<0,01$).

Although there were no significant differences for energy and for total carbohydrate and protein intakes in absolute amounts, when expressed as percentages of total energy intake, significant differences appeared among strata for carbohydrate, protein and fat, as can be seen from Figures 8.5 and 8.6 for females and males respectively.

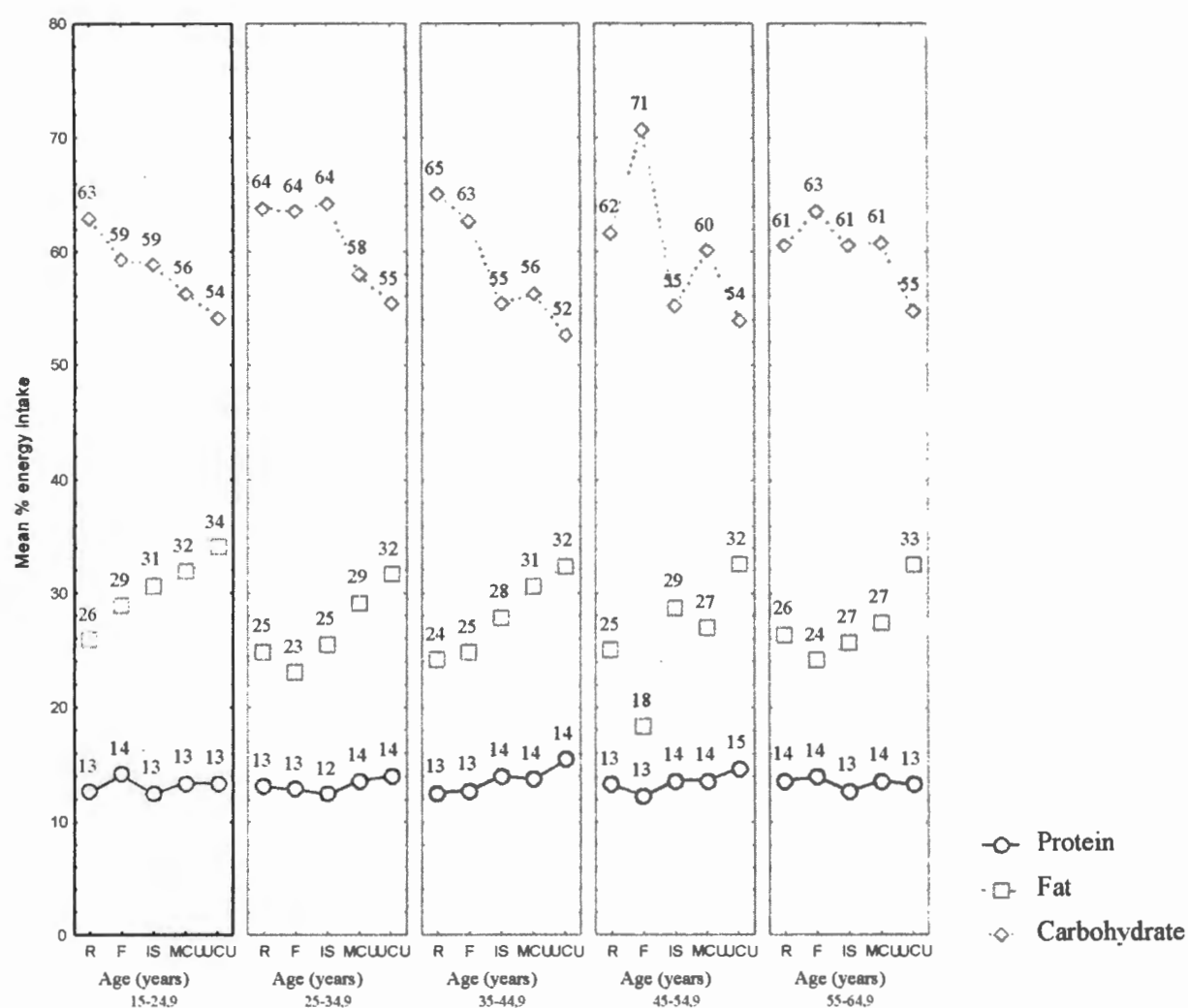


Figure 8.5: Females: Percentage of total energy intake provided by carbohydrate, protein and fat according to age group and stratum of urbanisation (N=552).

From Figure 8.5, the percentage of total energy provided by protein is fairly constant across all strata for the females. Only in the 35 to 44,9-year age group is the mean percentage energy (15,4% SD= 2,5) provided by protein for the upper class urban stratum significantly higher than that for the farm strata (12,8% SD=2,2) ($P<0,05$). However, there is a marked tendency for the proportion of carbohydrate to decrease from the rural and farm strata to the middle and upper class urban strata while the proportion of fat increases. The extent of these changes across strata varies among the different age groups. In the youngest age group, only the percentage of total energy from fat of the upper class urban stratum (34,0% SD=5,3) is significantly higher than that of the farm stratum (28,7% SD=8,6) ($P<0,001$), while, although the percentage of total energy from carbohydrates seems to decline fairly consistently (from 63% in the rural stratum to 54% in the upper class urban stratum), none of the differences is significant ($P>0,05$). In the 25 to 34,9-year age group, the mean percentage total energy from fat is significantly higher and the mean percentage total energy from carbohydrate significantly lower in the upper class urban stratum than the rural, farm and informal settlement strata ($P<0,001$). The pattern of the energy distribution in the age groups of 35 to 44,9 years and 45 to 54,9 years were similar with the only significant differences being between the upper class urban and farm strata ($P>0,05$). Although the eldest age group followed a similar pattern, no differences were significant, possibly because of the small numbers of subjects in these subgroups ($P>0,05$).

As for the females, the percentage energy contribution of protein did not differ significantly among strata in any of the age groups of the males ($P>0,05$). In the age group of 35 to 44,9 years, the percentage of total energy from carbohydrate (51,2% SD= 6,5) was significantly lower for the upper class urban stratum than for the farm stratum (68,8% SD=10,1) ($P<0,05$) while the percentage total energy provided by fat was significantly higher for the upper class urban stratum (32,4% SD=5,1) than the farm stratum (22,1% SD=8,5) ($P<0,001$). There were no significant differences in the energy distribution of the upper two age groups ($P>0,05$).

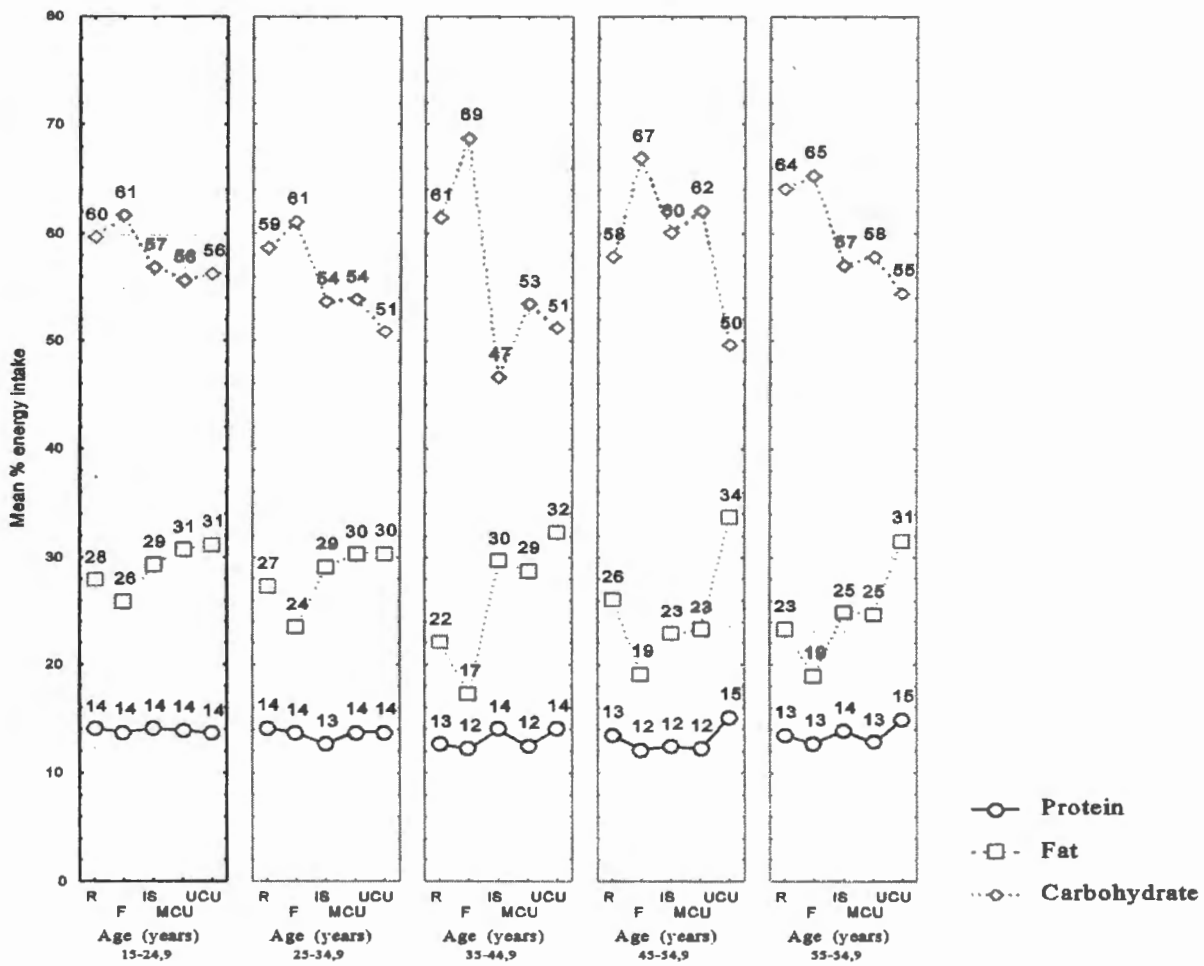


Figure 8.6: Males : mean percentage energy distribution of carbohydrate, protein and fat according to age group and stratum of urbanisation (N=338)

From Figures 8.5 and 8.6 and Tables 8.9 and 8.10, it is clear that the total fat content of the diet changed across strata of urbanisation. It may also be expected that the proportions of saturated, monounsaturated and polyunsaturated fat would change with the stratum of urbanisation. Figures 8.7 and 8.8 illustrate the percentages of total fat provided by saturated, polyunsaturated and monounsaturated fats for the females and males respectively.

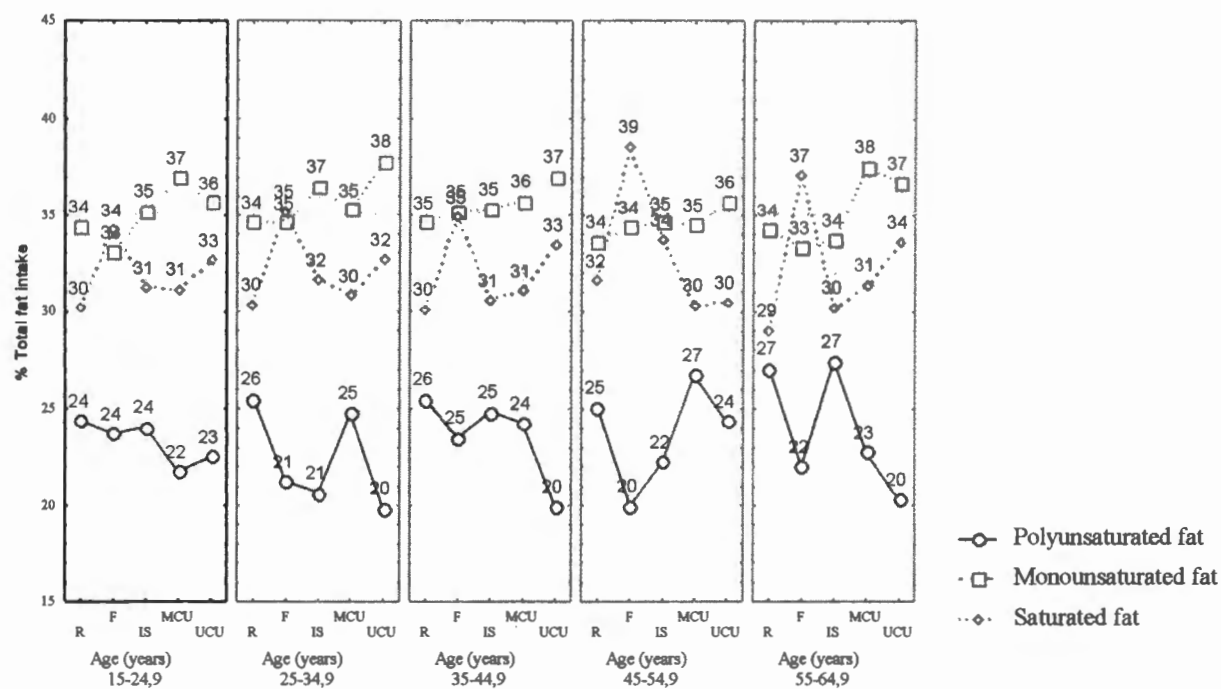


Figure 8.7: Females: mean percentage saturated, monounsaturated and polyunsaturated fat of total fat intake according to age group and stratum of urbanisation (N=552).

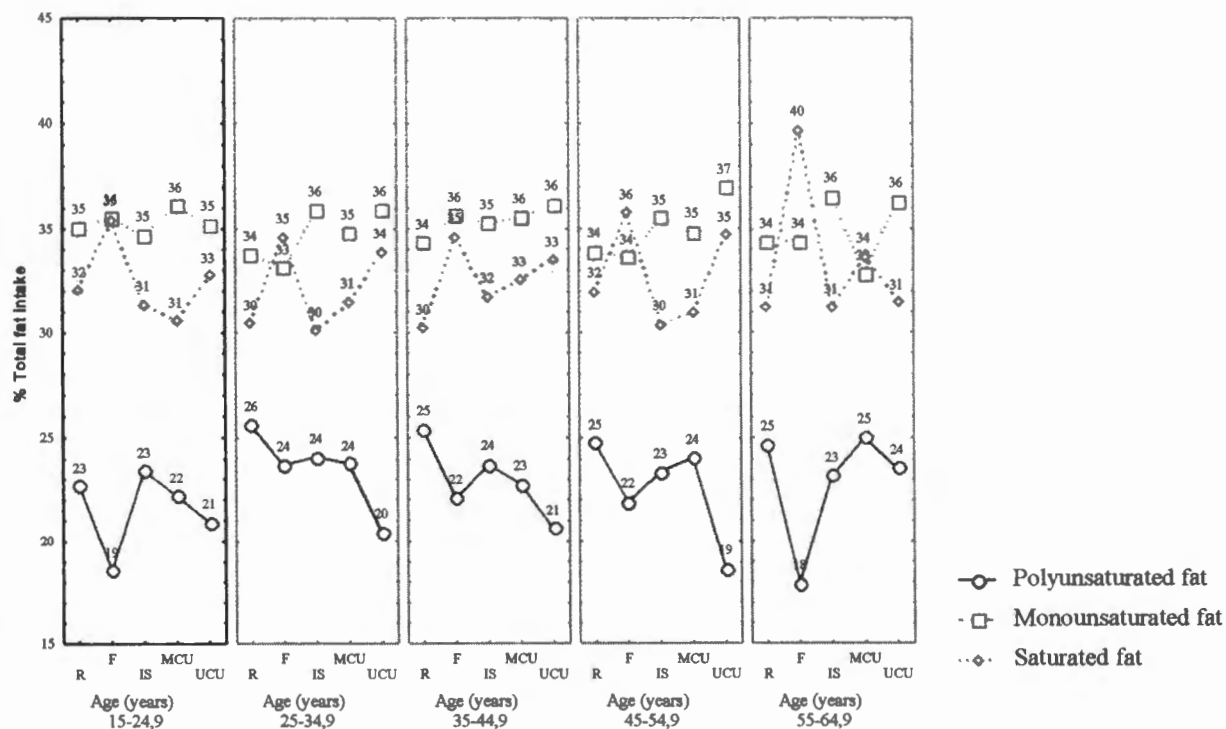


Figure 8.8: Males: mean percentage saturated, monounsaturated and polyunsaturated fat of total fat intake according to age group and stratum of urbanisation (N=338).

Although the mean percentages of fat provided by saturated and monounsaturated fatty acids appear to differ among strata, statistically significant differences occurred only between strata for polyunsaturated fat with the more urbanised strata having lower mean intakes than the rural and farm strata. Among the females, the mean percentage of polyunsaturated fat of the upper class urban subjects in the 25 to 34,9-year, 35 to 44,9-year and 45 to 54,9-year age groups (20,5% SD=5,1, 20,6% SD=4,1 and 18,7% SD=3,9 respectively) was significantly lower than that of rural subjects (25,6% SD=5,9, 25,4 SD=6,3 and 24,7% SD=6,0) ($P<0,01$). For the males, the only significant difference was seen in the 45 to 54,9-year age group where the mean percentage polyunsaturated was significantly lower in the farm stratum (20,0% SD= 5,3) than in the middle class urban stratum (26,7% SD=6,0) ($P<0,01$). It follows that the P:S ratio (Tables 8.9 and 8.10) showed few differences among strata of urbanisation. The overall mean P:S ratio for the whole sample was 0,76 (SD=0,31). The mean ratios of the subgroups within the rural stratum came closest to the recommended ratio of one (American Heart Association, 1986). In most age groups, the lowest ratio was found in the upper class urban stratum. Among the females, there were significant differences between the P:S ratios of the rural and upper class urban strata in the 25 to 34,9-year, 35 to 45,9-year and 45 to 54,9-year age groups ($P<0,01$). The only significant difference among the males, was in the 45 to 54,9-year age group, where, by contrast to the females, the mean P:S ratio of the middle class urban stratum was significantly higher than that of the farm stratum ($P<0,01$).

8.2.5 Mineral intake

The means and standard deviations of the reported mineral intakes for females and males according to stratum of urbanisation and age group are shown in Tables 8.11 and 8.12. The adjusted intakes for calcium and iron are also shown.

8.2.5.1 Calcium

The mean reported calcium intakes are low, with those of most subgroups falling below 67% RDA (800 mg and 536 mg for 1200 mg and 800 mg respectively). Only the mean calcium intakes of the farm worker stratum in some subgroups (females: 25 to 34,9-years; 55 to 64,9-years; males: 45 to 54,9-years; 55 to 64,9-years) and the upper class urban stratum (females: 45 to 64,9-years) exceeded

67% RDA. After adjustment for constant and proportional bias, mean intakes were increased for all subgroups. In some cases, for example the 25 to 34-year age groups of males and females in the farm worker stratum, the adjusted mean intakes are impossibly high. The reasons for this could be the wide variation in individual intakes (intakes ranged from 5 mg to 1800 mg for the entire sample with coefficients of variation of between 49% and 60% for the various age groups) as well as the small sample sizes. The adjusted values for the entire sample in each age group appear more reasonable, but are still higher than the reported intake. Since the median is not affected by the variation of the sample, the adjustment for constant and proportional bias was applied to the median intakes. The adjusted medians appeared more reasonable than the adjusted means. By way of illustration, the median and adjusted median intakes for males and females, combined for age groups are shown in Table 8.13. The higher median intakes (greater than 400 mg) were increased, while the lower median intakes decreased. Thus, it appears that higher calcium intakes were underestimated while lower intakes were overestimated. Despite the farm stratum showing higher mean and median intakes, there were no significant differences in reported mean intakes among strata in any of the age groups ($P>0,05$).

Table 8.11: Females: mean reported mineral intakes according to age group and stratum of urbanisation (N=552)

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		
	‡RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	P-value
		Age group: 15 to 24,9 years (N=108)												
		N=30		N=11		N=17		N=18		N=32		N=108		
Calcium (mg)	1200	450,4	178,6	604,5	348,6	405,1	247,3	452,2	226,5	440,6	192,3	456,4	225,4	
Adjusted calcium(mg)		742,5	949,5	2860	3937	944,4	1968,6	1044,1	2155,5	742,0	1005	1040	1922	
Iron (mg)	15	9,8	2,6	8,4	6,6	7,8	2,7	10,3	4,0	9,8	3,3	9,4	3,6	
Adjusted iron (mg)		14,4	11,0	24,8	61,1	8,2	8,9	19,6	19,8	15,9	15,4	15,8	23,3	
Magnesium (mg)	280	332,0	67,3	234,7	77,2	271,1	61,9	305,8	122,2	266,2	88,5	288,7	89,9	
Potassium (mg)		2168	583,4	1844	600,3	1962	491,7	2370	898,6	2189	737,2	2142	686,8	
Sodium (mg)		1490	748,0	1100,5	703,8	1437	575,6	1789	836	1841	706,4	1596	748	
Zinc (mg)	12	9,5	2,3	7,9	3,3	7,8	2,4	10,2	4,0	10,2	3,8	9,4	3,3	
		Age group 25 to 34,9 years (N=151)												
		N=28		N=15		N=27		N=50		N=31		N=151		
Calcium (mg)	800	437,6	219,1	645,5	302,6	375,7	196,0	444,8	233,7	524,0	300,4	467,3	255,8	
Adjusted calcium(mg)		856,6	1359	3068	4573	534,9	804,4	1032	1941	2043	3954	1321	2710	
Iron (mg)	15	8,4	3,6	8,7	4,2	8,4	3,8	9,4	3,5	11,1	4,9	9,3	4,04	
Adjusted iron (mg)		11,5	11,8	13,8	8,5	12,2	11,2	15,2	9,5	27,7	17,0	16,4	24,0	
Magnesium (mg)	280	310,6	134,6	322,3	106,8	303,8	122,9	318,0	107,3	318,1	107,3	299,6	91,9	
Potassium (mg)		2032	780,1	2298	577,6	2104	791	2368	753	2451	931	2269	796	
Sodium (mg)		1257	773,7	1094	447,5	1465	866	1561	683	1653	664,8	1460	727,9	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	P-value
Zinc (mg)	12	8,1a	2,8	7,9	2,7	8,3	3,3	9,7	2,9	10,6a	3,5	9,2	3,2	a*
		Age group: 35 to 44,9 years (N=127)												
		N=32		N=14		N=18		N=30		N=33		N=127		
Calcium (mg)	800	397,1	289,8	572,7	333,4	431,8	208,0	417,9	151,0	522,5	256,7	458,9	252,9	
Adjusted calcium(mg)		1429	4964	2524	3955	811,7	1484	530	643,0	1914	6070	1376	4227	
Iron (mg)	15	8,3a	3,2	5,9	3,1	8,0	3,6	8,3	2,8	10,1a	3,5	8,5	3,5	a**
Adjusted iron (mg)		10,6	11,8	5,1	8,5	10,2	11,2	9,8	9,5	17,5	17,0	11,6	12,9	
Magnesium (mg)	280	305,7	124,1	250,4	110,2	296,1	136,0	288,6	86,7	288,0	91,9	289,6	108,0	
Potassium (mg)		2008	820,5	1892	729,0	2035	580,8	2147,3	521,6	2417	725,5	2138,7	703,7	
Sodium (mg)		1098a	511,2	1043,6	546,1	983,2	557,5	1497,1	848,5	1564a	699,0	1291	697,3	a*
Zinc (mg)	12	7,8	2,7	6,7	3,6	7,9a	2,6	8,9	3,1	10,9a	3,1	8,8	3,5	a*
		Age group: 45 to 54,9 years (N=102)												
		N=32		N=13		N=10		N=28		N=19		N=102		
Calcium (mg)	800	525,1	256,6	485,2	363,9	393,7	223,8	395,3	209,9	603,2	238,2	486,0	261,7	
Adjusted calcium(mg)		1576	2502	2212	5143	651	969	800,1	2362	2026	2687	1437	2878	
Iron (mg)	10-15	9,7	3,5	4,7a	2,6	10,0	4,9	7,7b	3,01	11,1ab	4,1	8,8	4,0	a***; b*
Adjusted iron (mg)		15,7	16,0	2,5	3,3	20,6	21,6	8,6	12,0	24,6	36,7	14,2	21,0	
Magnesium (mg)	280	351,2	109,3	217,2	125,8	309,9	140,5	286,46	103,1	304,7	127,3	303,6	121,7	
Potassium (mg)		2317	671,4	1639a	753,4	2249	832,6	2029,8	557,9	2580,7a	919,7	2194	762,8	a**
Sodium (mg)		1350	582,0	702,4a	624,2	1291,6	728,0	997,9b	437,8	1716ab	958	1233,5	716,2	a***; b**

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	P-value
Zinc (mg)	12	9,9	3,4	5,3	2,7	8,6a	4,0	7,9	2,5	10,8a	3,8	8,8	3,6	a***
		Age group: 55 to 64,9 years (N=63)												
		N=30		N=6		N=8		N=16		N=3		N=63		
Calcium (mg)	800	435,5	229,2	751,2	366,7	437,9	228,8	436,1	331,3	567,0	132,5	471,7	277,9	
Adjusted calcium(mg)		909,7	1524	4872	6514	893	1560	1967	5814	1113	923,6	1553	3765	
Iron (mg)	10	9,5	6,2	4,9	1,1	8,3	3,2	7,5	3,3	12,8	2,2	8,6	5,0	
Adjusted iron (mg)		28,8	12,3	1,8	16,2	9,8	14,3	8,2	18,4	27,6	40,2	18,7	51,4	
Magnesium (mg)	280	305,4	133,5	232,7	76,3	333,9	128,5	263,6	105,6	375,7	25,6	295,0	121,0	
Potassium (mg)		2166	737,9		717,0	2057	2034	1948	702	3062	442,7	2127,9	727,5	
Sodium (mg)		1062a	477,1	895,3	463,7	1305	666,1	881,3b	421,6	2105,7ab	490,2	1080,5	542,8	a,b*
Zinc (mg)	12	8,8	3,8	6,4	1,5	8,6	2,7	6,8	2,4	13,3	2,4	8,3	3,4	

*P<0,05; **P<0,01, ***P<0,001; † Standard deviation; a,b,c: strata for which mean intakes differ significantly; Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

Table 8.12: Males: mean reported mineral intakes according to age group and stratum of urbanisation (N=338)

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
		¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	
		Age group: 15 to 24,9 years (N=110)												
		N=27		N=16		N=14		N=18		N=35		N=110		
Calcium (mg)	1200	533,8	314,4	585,0	342,2	550,0	343,1	664,2	282,0	575,4	276,3	538,9	306,2	
Adjusted calcium(mg)		2423	5553	3331	7693	2800	6437	2926	3644	2313	5048	2650	5531	
Iron (mg)	10	10,1	3,4	6,6ab	3,1	9,2	4,1	11,6a	4,7	11,0b	4,1	9,3	4,2	a* ; b*
Adjusted iron (mg)		18,2	22,1	5,9	7,1	15,7	22,3	29,4	41,6	23,6	25,0	19,6	26,6	
Magnesium (mg)	350	353,1	153,6	250,0a	109,9	313,1	132,5	395,0a	148,2	355,1	116,9	341,7	136,2	a*
Potassium (mg)		2342	773,1	1906	772,4	2005	1104	2842	1041	2632	223	2450	945	
Sodium (mg)		1845a	801	1058abc	552	1395	733,5	2144c	881	1885b	790	1735	833,9	a* ; b** ; c*
Zinc (mg)	15	10,6	5,0	7,5a	2,9	9,8	4,7	12,0a	4,2	11,7	4,3	10,6	4,5	a*
		Age group 25 to 34,9 years (N=70)												
		N=11		N=15		N=7		N=17		N=20		N=70		
Calcium (mg)	800	497,5	302,7	604,1	425,4	622,6	237,3	438,3	171,1	420,3	143	496,4	272,0	
Adjusted calcium(mg)		1896	4106	4265	8730	2141	2972	644,8	760,9	499,3	498,2	1721	5585	
Iron (mg)	10	9,29	5,6	6,71	3,2	10,9	2,4	9,6	3,1	9,8	2,9	9,1	3,7	
Adjusted iron (mg)		20,9	22,1	6,5	7,1	18,2	22,3	14,3	41,6	15,0	25,0	14,2	16,7	
Magnesium (mg)	350	328,4	170,3	316,7	149,1	395,6	116,3	351,0	104,7	336,5	97,2	340,4	124,6	
Potassium (mg)		2173	890,0	1960	851,1	2655,4	568,7	2339	534,7	2489	600,4	2306	712,0	
Sodium (mg)		1241	739,5	984,6a	507,3	1796	694,8	1548	653,8	1819a	851,1	1481,4	761,0	a*

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	P-value
Zinc (mg)	15	9,0	4,3	8,0	2,9	11,9	5,5	10,6	3,9	11,2	3,0	10,1	3,9	
		Age group 35 to 44,9 years (N=58)												
		N=15		N=11		N=6		N=11		N=15		N=58		
Calcium (mg)	800	512,6	285,3	527,1	299,3	384,5	184,7	502,2	246,7	494,1	222,1	495,3	251,1	
Adjusted calcium(mg)		1594	2303	1710	2160	467	562	1281	1635	1154	1719	1326	1865	
Iron (mg)	10	10,5	3,9	6,1a	2,0	10,0	3,6	9,7	3,7	10,3a	3,5	9,4	3,7	a*
Adjusted iron (mg)		19,7	15,7	3,8	4,4	16,2	12,0	16,5	22,8	18,4	19,6	15,4	17,2	
Magnesium (mg)	350	439,5	177,6	310,2	69,0	358,0	225,0	376,3	83,7	308,0	98,8	360,5	139,8	
Potassium (mg)		2668	961,0	1989	428,4	2255	767,1	2548	674,1	2337	731,2	2388	761,9	
Sodium (mg)		1467	762	743	541	1074	541,0	1619	754	1593,7	892,4	1351	781	
Zinc (mg)	15	10,4	3,6	6,8	1,8	10,2	3,7	11,5	5,7	10,6	4,2	9,9	4,2	
		Age group: 45 to 54,9 years (N=61)												
		N=11		N=19		N=8		N=16		N=7		N=61		
Calcium (mg)	800	616,4	467,5	705,5	275,4	376,1	220,2	477,0	215,2	372,4	131,1	548,1	309,4	
Adjusted calcium(mg)		6395	18091	3302	3641	619,2	1090	990,6	1231	58,6	325,7	2560	7979	
Iron (mg)	10	9,7	3,4	6,8	3,4	6,7	3,2	8,0	2,4	9,7	2,8	8,0	3,2	
Adjusted iron (mg)		15,6	16,7	7,3	10,5	5,9	5,5	8,2	7,9	13,8	9,5	9,6	12,5	
Magnesium (mg)	350	345,9	128,4	337,6	156,2	318,3	131,3	393,8	116,8	303,0	99,5	349,0	132,0	
Potassium (mg)		2438	860,8	2248	591,9	1950	601,2	2243	631,8	2254,7	581,6	2242	650,2	
Sodium (mg)		1331	582,8	832,6	428,2	983,8	355,2	1171	464,9	1058	445,6	1057	484	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	P-value
Zinc (mg)	15	9,8	4,4	7,8	3,4	7,3	2,6	8,6	2,2	10,7	4,1	8,7	3,4	
		Age group: 55 to 64,9 years (N=39)												
		N=14		N=8		N=6		N=9		N=2		N=39		
Calcium (mg)	800	345,1	194,8	612,6	362	426,7	125,2	423,1	244,2	412,5	89,8	434,0	248,5	
Adjusted calcium(mg)		403,9	549,0	3354	6560	449,7	263,5	890,2	1406	351,4	243,0	1125	3125	
Iron (mg)	10	9,5	5,1	6,3	2,1	7,8	4,4	7,8	4,4	8,0	3,8	10,1	4,5	
Adjusted iron (mg)		19,1	19,8	3,9	2,5	10,7	13,0	10,6	12,3	16,2	16,6	12,5	15,1	
Magnesium (mg)	350	338,0	168,7	317,4	125,1	355,8	192,7	370,3	133,5	319,0	127,3	343	148,5	
Potassium (mg)		2147	962,0	2006	743,2	2152	1011	2257	850,7	2279	433,5	2151	847	
Sodium (mg)		1219	820,8	908,8	451,5	1175	888,0	1238	769,2	1385	461	1161	721,6	
Zinc (mg)	15	9,5	5,0	6,7	2,1	7,7	3,7	9,7	4,2	10,3	2,8	8,7	4,1	

*P<0,05; **P<0,01; ***P<0,001; ¶Recommended dietary allowance; † Standard deviation; a,b,c: strata for which mean intakes differ significantly; Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

Table 8.13: Median reported and adjusted calcium intakes for females and males according to stratum of urbanisation (N=890)

		Stratum of urbanisation				
Gender		Rural	Farm	Informal settlement	Middle class urban	Upper class urban
Females	Number	153	59	80	142	115
	Reported median (mg)	417,0	520,0	347	384,0	481
	Adjusted median (mg)	331,5	709,8	176,0	250,7	542,5
Males	Number	78	69	41	71	79
	Reported median (mg)	432,0	589,0	433	470	446
	Adjusted median (mg)	375,2	1090,0	377,5	501,0	418,0

As can be seen from Tables 8.11 and 8.12, most of the reported mean calcium intakes indicate a considerable risk of calcium deficiency (mean intakes below 67% RDA) in the population. After adjustment for constant and proportional bias, mean calcium intakes appeared adequate. When the medians were used, adjustment resulted in low intakes decreasing (increasing the risk of deficiency). Figures 8.9 and 8.10 present the percentages of subjects with individual calcium intakes below 67% RDA (according to actual intakes) for females and males respectively.

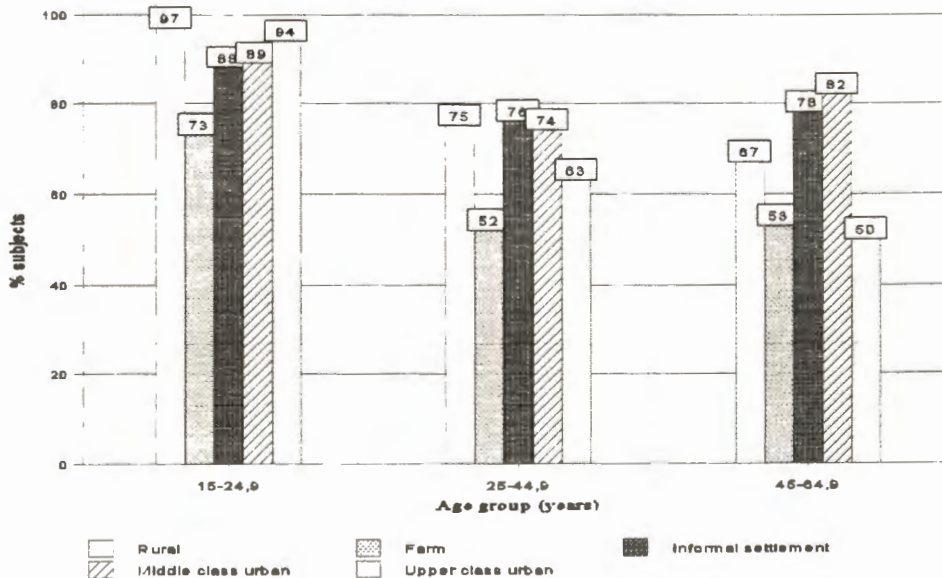


Figure 8.9: Percentage females with calcium intakes below 67% RDA according to age group and stratum of urbanisation (N=552)

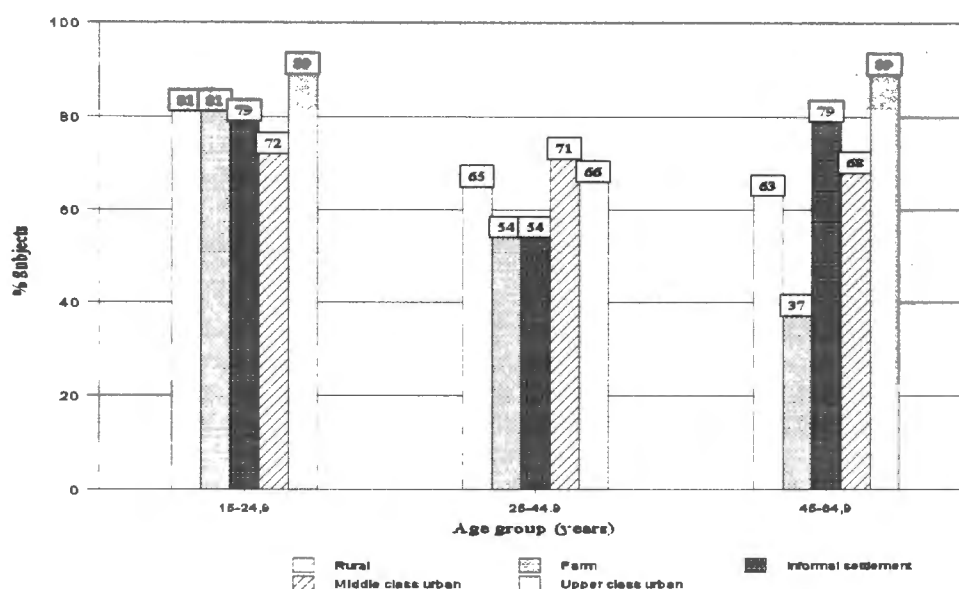


Figure 8.10: Percentage males with calcium intakes below 67% RDA according to age group and stratum of urbanisation (N=338)

There were no significant differences in the percentages of females with reported calcium intakes below 67% RDA in any of the age groups at the 1% level of significance. For the males, in the age group older than 45 years, the percentage of subjects from the farm worker stratum with intakes below 67% RDA was significantly lower than that of the informal settlement stratum ($P<0,01$).

8.2.5.2 Iron

The mean reported iron intakes of the farm worker stratum for both females and males were below 67% RDA (10 mg for females and 6,7 mg for males and postmenopausal females) in all age groups. For the females, the difference in reported mean iron intakes between the upper class urban stratum and the farm worker stratum was significant for the 35 to 44,9-year and 45 to 54,9-year age groups ($P<0,01$) and between the middle class urban and upper class urban strata for the 45 to 54,9-year age group ($P<0,01$). For the males, the mean reported iron intake was significantly lower in the farm stratum than in both the middle class urban and upper class urban strata in the 15 to 24,9-year age group and the upper class urban stratum in the 35 to 44,9-year age group ($P<0,05$). After adjustment for constant and proportional bias, the mean intakes improved in all subgroups except

those of the farm worker stratum where mean iron intakes were less than 6,6 mg.

The comparisons of the proportions of subjects with iron intakes which indicate a risk of deficiency are shown in Figures 8.11 and 8.12 respectively.

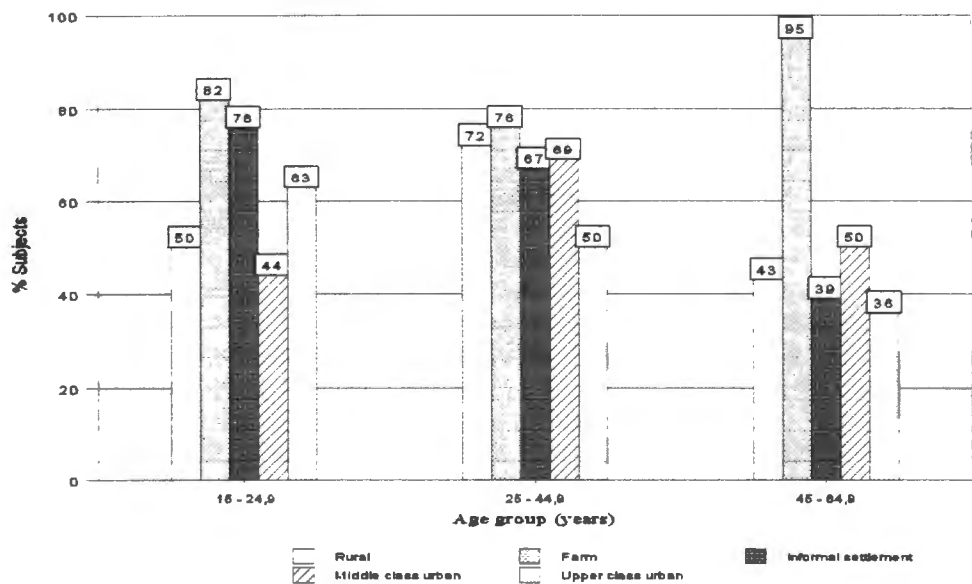


Figure 8.11: Percentage females with iron intakes below 67% RDA according to age group and stratum of urbanisation (N=552)

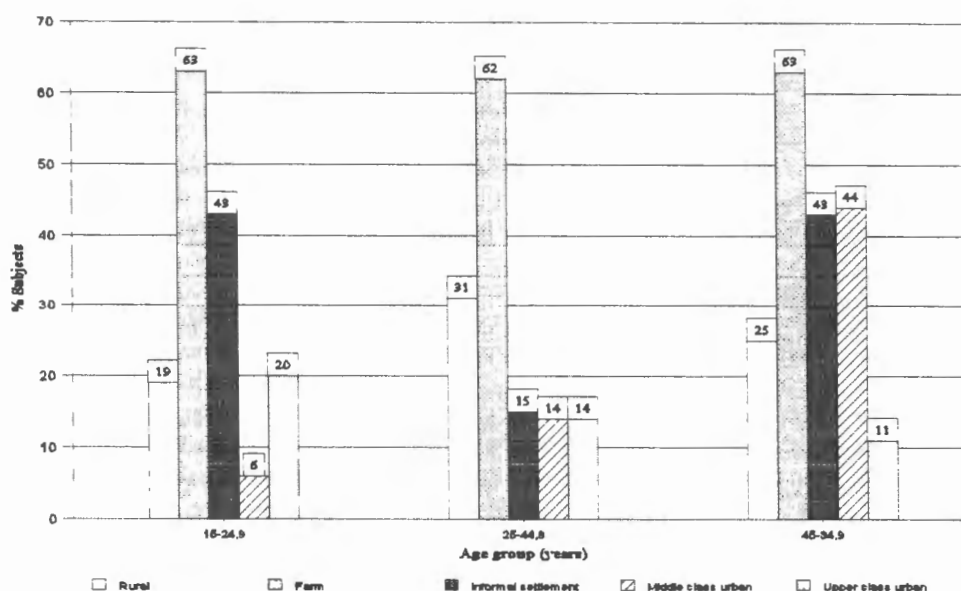


Figure 8.12: Percentage males with iron intakes below 67% RDA according to age group and stratum of urbanisation (N=338)

Clearly from the above graphs, the highest percentage of subjects at risk of an iron deficiency was in the farm worker stratum in all age groups. Among the females, no difference in percentages between strata in the youngest age group was significant ($P>0,01$). However, in the 25 to 44,9-year age group, the differences between the rural and upper class urban strata and between the farm worker stratum and the upper class urban stratum were significant ($P<0,01$). In the eldest age group of the females, the percentage of subjects with iron intakes below 67% RDA was significantly lower than that of all four other strata ($P<0,01$). Among the males, significant differences occurred in the youngest age group between the farm worker stratum and the rural, middle class urban and upper class urban strata and in the eldest age group between the farm worker stratum and the rural stratum ($P<0,01$).

8.2.5.3 Magnesium and zinc

Fewer significant differences occurred between strata for magnesium and zinc than for calcium and iron. The only significant difference for magnesium occurred in the males aged between 15 and 24,9

years, where the mean reported intake of the farm workers was significantly lower than that of the subjects in the middle class urban stratum ($P<0,05$). In the case of zinc, significant differences appeared in the females among the 25 to 34,9, 35 to 44,9 and 45 to 64,9-year age groups and in the males, in the 15 to 24,9-year age group. Since magnesium is widely distributed in nature and particularly in grains and legumes, risk of deficiency seems unlikely even among the farm worker stratum, where the diet appears poor in other respects. Zinc intakes were below 67% RDA (8 mg) in all age groups of the farm stratum, reflecting the low meat intake. The percentage of subjects with zinc intakes below 67% RDA for the farm stratum was 75% as opposed to 44% for the other four strata combined.

8.2.5.4 Sodium and potassium

The mean sodium intakes given in Tables 8.11 and 8.12 reflect only sodium occurring naturally in foods and from salt used as an ingredient in cooked dishes or in commercial snacks such as potato crisps or salted peanuts. Reported intakes did not include salt added to food. Thus, these intakes are probably an underestimation of the actual sodium intake of the population. This is supported by the responses of the subjects to the questions regarding salt use, asked at the conclusion of the interview (Appendix F). In response to the question regarding the addition of salt to food during cooking, 87% of subjects said that they always added salt and 7% sometimes added salt during cooking. The percentage of subjects who added salt during food preparation was significantly higher in the upper class urban stratum (94%) than the percentages in the rural, farm and informal settlement strata (84%, 82% and 81% respectively) ($P<0,001$). Slightly more than half the subjects (52%) sometimes or always added salt to prepared food, while 78% liked salty foods. There were no significant differences in the proportions of responses to the last two questions from the different strata of urbanisation ($P>0,05$).

Among the females, the highest mean sodium intakes appeared to be in the upper class urban subjects with significant differences in the 35 to 44,9-year, 45 to 54,9-year and 55 to 64,9-year age groups ($P<0,05$). The only significant differences among the males occurred in the 15 to 25-year age group, where the mean intake of the farm worker stratum was significantly lower than that of the rural, middle class urban and upper class urban strata ($P<0,05$).

Mean reported potassium intakes were lower in the farm worker stratum than in the other strata, but only the difference between the upper class urban stratum and the farm stratum for females in the 45 to 54,9-year age group was significant. The low intakes in the farm stratum could be explained by the low intake of animal protein.

8.2.6 Vitamin intake

The mean reported intakes of vitamins for females and males, according to age group and stratum of urbanisation are shown in Tables 8.14 and 8.15 respectively.

Table 8.14: Females: mean reported vitamin intakes according to age group and stratum of urbanisation (N=552)

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group: 15 to 24,9 years (N=108)												
		N=30		N=11		N=17		N=18		N=32		N=108		
Vitamin A (RE)	800	819,8	811,8	920,0	753,8	847,1	526,1	895,8	567,8	1015,6	895,8	903,3	750,4	
Adjusted vitamin A (RE)	800	1287	3515	1218	1615	805,5	1041	928,2	1519	1840	5070	1309	5755	
Vitamin E (mg)	8	9,62	3,96	7,24	3,38	11,16	6,20	11,00	4,54	10,85	4,39	10,21	4,61	
Thiamin (mg)	1,1	1,23	0,27	0,95	0,35	1,06	0,25	1,17	0,46	1,06	0,33	1,11	0,33	
Riboflavin (mg)	1,3	1,60	0,51	1,6	0,75	1,31	0,50	1,45	0,46	1,56	0,57	1,52	0,55	
Niacin (mg)	15	13,98	3,87	9,43ab	5,72	14,03	4,29	16,27a	5,33	15,28b	4,93	14,29	4,98	a*,b**
Vitamin B6 (mg)	1,6a	1,16	0,43	0,90b	0,38	1,22	0,45	1,39	0,59	1,53ab	0,59	1,29	0,54	a,b*
Vitamin B12 (ug)	2,0	4,56	3,2	7,8	7,1	6,02	5,00	4,90	3,45	6,74	5,5	5,92	4,81	
Folic acid (ug)	180	205,7	103,2	160,5	40,6	178,1	74,06	241,2	98,78	182,28	63,26	195,7	84,7	
Vitamin C (mg)	60	44,87a	38,0	24,0b	16,04	31,24c	19,18	77,83	63,92	82,15abc	79,16	57,14	58,79	a,c**, b*
Adjusted vitamin C (mg)		30,00	29,4	14,53	10,81	19,52	13,35	56,07	51,78	59,93	68,71	40,0	48,0	
		Age group 25 to 34,9 years (N=151)												
		N=28		N=15		N=27		N=50		N=31		N=151		
Vitamin A (RE)	800	498,2	439,7	849,5	639,4	1091,8	1332,1	1020,6	822,0	1173,2	968,7	950,8	918,5	
Adjusted vitamin A (RE)	800	351,7	1014,3	953,6	1392,7	3474,7	12324	1617	2877	2271	3676	1783	5756	
Vitamin E (mg)	8	9,67	5,11	11,01	6,0	10,1	6,6	11,8	8,2	10,8	7,40	10,80	7,01	
Thiamin (mg)	1,1	1,16	0,53	1,19	0,37	1,20	32,4	1,19	0,41	1,22	0,45	1,19	0,46	

Nutrient		Stratum of urbanisation												P-value
		R		F		IS		MCU		UCU		Entire sample		
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
Riboflavin (mg)	1,3	1,27a	0,55	1,73	0,79	1,55	0,83	1,54	0,57	1,90a	0,96	1,59	0,75	a*
Niacin (mg)	15	12,80	6,49	11,67	5,57	15,88	6,21	16,07	5,4	16,90	6,23	15,16	6,14	
Vitamin B6 (mg)	1,6	0,94a	0,55	0,92b	0,33	1,23	0,57	1,31	0,55	1,50ab	0,63	1,23	0,58	a**; b*
Vitamin B12 (ug)	2,0	8,38	3,63	8,67	4,17	8,44	3,80	9,44	3,51	11,06	4,92	9,32	4,04	
Folic acid (ug)	180	186,0	69,11	233,5	105,0	194,4	80,0	234,1	89,2	239,2	104,1	219,1	90,9	
Vitamin C (mg)	60	39,9	43,8	23,1	10,2	37,0	37,8	74,0	87,3	101,35	90,6	61,6	73,9	
Adjusted vitamin C (mg)		26,9	33,6	13,7	6,9	24,3	30,0	54,4	76,0	76,2	77,2	44,4	62,3	
		Age group: 35 to 44,9 years (N=127)												
		N=32		N=14		N=18		N=30		N=33		N=127		
Vitamin A (RE)	800	656,5	395,8	498,1	368,2	785,1	368,2	1031,0	1013,7	1384,2	952,7	934,8	831,5	
Adjusted vitamin A (RE)	800	439,5	560,1	276,4	524,1	1040,9	2215,1	2121,7	36,8	2835,3	55,6	1526	3621	
Vitamin E (mg)	8	8,29	4,46	9,16	5,09	8,97	5,45	9,95	5,16	10,84	5,39	9,53	5,11	
Thiamin (mg)	1,1	1,11	0,48	0,92	0,41	1,01	0,34	1,01	0,33	1,11	0,37	1,05	0,40	
Riboflavin (mg)	1,3	1,24	0,57	1,25	0,87	1,53	0,69	1,62	0,91	1,78	0,61	1,50	0,74	
Niacin (mg)	15	11,98	5,08	8,49	4,88	13,62	5,01	13,92	4,7	15,48	4,95	13,20	5,28	
Vitamin B6 (mg)	1,6	0,93a	0,46	0,74b	0,32	1,08	0,56	1,20	0,39	1,40ab	0,58	1,12	0,52	a,b**
Vitamin B12 (ug)	2,0	3,91	3,03	3,47	3,49	5,83	6,55	6,97	8,13	10,00	7,6	6,44	6,73	
Folic acid (ug)	180	194,0a	78,9	164,4b	62,1	163,6c	63,7	227,6	94,2	252,1abc	97,3	209,5	89,8	a, b, c *
Vitamin C (mg)	60	35,4a	24,0	17,0 b	7,79	25,4c	14,3	52,8	55,3	78,6abc	45,8	47,3	43,4	a,b,c ***
Adjusted vitamin C (mg)		22,6	17,2	9,6	4,9	15,4	9,5	36,8	43,9	55,6	36,6	32,1	33,8	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
		Age group: 45 to 54,9 years (N=102)												
		N=32		N=13		N=10		N=28		N=19		N=102		
Vitamin A (RE)	800	894,5	765,9	517,8	363,9	1446,5	1227,0	823,5	632,5	1739,6	1440,8	1038	984,0	
Adjusted vitamin A (RE)	800	1303,2	3130	278,3	343,6	3641,0	6018,2	953,0	2326,7	5796,0	12847	2142	6396	
Vitamin E (mg)	8	10,67	6,18	5,49	4,84	10,91	7,38	8,54	4,41	9,41	5,60	9,22	5,75	
Thiamin (mg)	1,1	1,21	0,39	0,81	0,44	1,1	0,43	1,01	0,34	1,16	0,50	1,08	0,42	
Riboflavin (mg)	1,3	1,46	0,67	1,03	0,58	1,82	1,03	1,34	0,49	1,75	0,75	1,46	0,70	
Niacin (mg)	15	14,55	5,27	6,93	3,12	14,8	5,71	12,91	5,10	15,52	6,33	13,33	5,79	
Vitamin B6 (mg)	1,6	1,03	0,43	0,61	0,31	1,36	0,79	0,98	0,29	1,50	0,60	1,08	0,53	
Vitamin B12 (ug)	2,0	5,60	7,00	3,41	2,86	11,80	12,82	5,71	5,90	9,29	8,29	6,65	7,62	
Folic acid (ug)	180	224,8	85,9	144,3	75,4	205,6	77,8	210,6	57,2	255,6	93,3	214,5	83,1	
Vitamin C (mg)	60	42,41	39,4	18,6	17,5	62,5	65,16	45,03	37,0	88,7	69,9	50,7	50,8	
Adjusted vitamin C (mg)	60	28,4	30,0	11,1	11,8	44,6	51,8	30,0	28,3	64,8	58,1	35,0	40,2	
		Age group: 55 to 64,9 years (N=63)												
		N=30		N=6		N=8		N=16		N=3		N=63		
Vitamin A (RE)	800	977,5	877,6	624,0	205,2	589,6	300,0	748,4	515,2	1699,3	1050	872,4	732	
Adjusted vitamin A (RE)	800	1734,8	5513,4	286,1	201,3	300,8	387,0	661,2	1038,3	3606,2	4299,00	1239	4000	
Vitamin E (mg)	8	8,95	4,4	6,5	1,9	8,6	3,9	8,08	3,3	15,2	7,1	8,8	4,22	
Thiamin (mg)	1,1	1,15	0,58	0,92	0,35	1,28	0,5	0,9	0,40	1,44	0,12	1,1	0,56	
Riboflavin (mg)	1,3	1,40	0,60	1,28	0,55	1,44	0,47	1,22	0,53	2,11	0,41	1,4	0,56	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	†RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
Niacin (mg)	15	12,4	5,4	7,3	2,4	14,4	6,7	10,83	3,8	18,53	1,42	12,08	5,30	
Vitamin B6 (mg)	1,6	0,98	0,39	0,74	0,23	0,89	0,36	0,87	0,36	1,52	0,51	0,95	0,39	
Vitamin B12 (ug)	2,0	5,78	6,48	3,38	1,50	4,31	3,15	4,48	4,8	13,0	8,7	5,38	5,7	
Folic acid (ug)	180	228,8	88,0	154,2	56,7	182,5	75,6	164,1	50,1	318,7	60,0	204,1	83,2	
Vitamin C (mg)	60	63,0	88,1	20,3	8,9	27,6	18,8	26,4	24,2	53,7	28,8	45,0	65,2	
Adjusted vitamin C (mg)		45,8	78,0	11,8	5,8	17,0	13,2	16,5	17,7	37,4	49,8	31,0	56,0	

*P<0,05; **P<0,01; ***P<0,001; ¶RDA: Recommended dietary allowance; † Standard deviation; a,b,c, d: strata for which mean intakes differ significantly; Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

Table 8.15: Males: mean reported vitamin intakes according to age group and stratum of urbanisation (N=338)

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	
		Age group: 15 to 24,9 years (N=110)												
		N=27		N=16		N=14		N=18		N=35		N=110		
Vitamin A (RE)	1000	587,0	331,0	400,2a	307,8	638,5	480,0	955,4a	677,4	882,0	685,4	706,8	556,4	a*
Adjusted vitamin A (RE)		326,8	477,0	124,7	134,0	532,5	19,7	1210	41,4	1035,3	55,4	693	1590	
Vitamin E (mg)	10	11,3	3,6	9,2	5,2	12,3	7,9	14,3	7,9	13,0	8,4	12,2	6,3	
Thiamin (mg)	1,5	1,24	0,42	0,92a	0,40	1,14	0,50	1,36	0,50	1,39a	0,45	1,25	0,47	a*
Riboflavin (mg)	1,7	1,28ab	0,53	1,21c	0,69	1,58	0,30	1,98ac	0,55	1,86b	0,82	1,61	0,33	a, b, c *
Niacin (mg)	19	15,3	6,2	10,2ab	4,9	12,0	5,01	20,3a	3,34	18,1b	6,1	16,2	6,8	a***;b**
Vitamin B6 (mg)	2,0	1,18a	0,33	0,92bc	0,35	1,34	0,39	1,61b	0,67	1,44ac	0,33	1,36	0,65	a, b, c *
Vitamin B12 (ug)	2,0	4,39	2,49	3,10a	4,79	5,39	3,68	7,82a	5,67	6,05	5,56	5,41	4,52	a*
Folic acid (ug)	200	242,4	91,5	158,5	57,0	240,3	97,4	276,1	106,0	243,1	90,3	234,2	95,6	
Vitamin C (mg)	60	38,3a	28,0	22,2b	17,8	31,1c	25,9	59,6	50,1	77,2abc	58,9	50,9	43,2	a, c* ; b**
Adjusted vitamin C (mg)		24,7	21,1	13,4	12,3	19,7	19,1	41,1	39,6	55,4	46,9	35,0	36,0	
		Age group 25 to 34,9 years (N=70)												
		N=11		N=15		N=7		N=17		N=20		N=70		
Vitamin A (RE)	1000	768,5	808,3	386,1a	358,3	527,7	344,1	856,8	622,3	1031a	612,4	759,1	619,4	a*
Adjusted vitamin A (RE)		1122	16,8	197,3	466,0	271,0	13,6	969,5	1952	1247	1739	897	1667	
Vitamin E (mg)	10	10,7	4,1	7,1a	3,7	12,2	6,4	12,0a	6,4	12,0	5,02	9,7	3,9	a*

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	QRDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	
Thiamin (mg)	1,5	1,06	0,50	1,09	0,47	1,24	0,49	1,26	0,37	1,16	0,30	1,16	0,41	
Riboflavin (mg)	1,7	1,33	0,60	1,41	0,74	1,74	0,59	1,63	0,45	1,52	0,34	1,52	0,54	
Niacin (mg)	19	14,5	8,4	11,1ab	6,63	19,1	7,01	19,0a	5,2	19,9b	4,6	16,9	6,9	a*; b**
Vitamin B6 (mg)	2,0	0,95	0,51	0,81	0,33	1,44	0,57	1,34	0,60	1,60	0,43	1,25	0,56	
Vitamin B12 (ug)	2,0	4,26	3,41	3,37	2,45	5,4	3,8	6,45	4,9	7,54	4,65	5,66	4,28	
Folic acid (ug)	200	192,7	95,4	169,5	91,9	231,8	94,9	231,3	97,7	229,8	65,4	211,6	88,8	
Vitamin C (mg)	60	27,2a	19,9	17,8b	10,5	22,7c	15,5	30,4d	14,8	77,5abcd	60,9	39,9	42,0	
Adjusted vitamin C (mg)		16,8	14,0	10,3	6,9	13,6	10,8	18,7	10,3	55,8	48,2	26,7	32,7	
		Age group: 35 to 44,9 years (N=58)												
		N=15		N=11		N=6		N=11		N=15		N=58		
Vitamin A (RE)	1000	744,5	728,2	539,4	506,5	1813	1944	416,4	242,0	1416	1031	927,7	1006	
Adjusted vitamin A (RE)		962,5	2085	418,1	790	7629	12502	143,3	131,1	3082	5189	1941	5155	
Vitamin E (mg)	10	11,4	6,8	6,9	3,8	11,6	5,9	12,8	5,12	10,9	5,08	10,7	5,6	
Thiamin (mg)	1,5	1,45	0,39	1,14	0,36	1,03	0,21	1,22	0,33	1,17	0,40	1,23	0,38	
Riboflavin (mg)	1,7	1,67	0,67	1,23	0,42	1,87	0,80	1,59	0,37	1,80	0,70	1,62	0,62	
Niacin (mg)	19	18,61a	7,0	9,92ab	4,26	18,4	7,43	20,43b	5,39	16,67	5,26	16,79	6,69	a**; b***
Vitamin B6 (mg)	2,0	1,24	0,63	0,63ab	0,26	1,19	0,51	1,43a	0,62	1,36b	0,49	1,19	0,58	a* ; b***
Vitamin B12 (ug)	2,0	4,77	4,11	3,91	4,83	13,80	19,02	3,9	2,1	8,58	8,69	6,37	8,33	
Folic acid (ug)	200	240,7	102,6	177,1	74,0	247,8	130,5	230,5	59,6	227,1	88,2	223,9	90,2	
Vitamin C (mg)	60	65,5	56,3	15,1	9,2	33,0	18,9	41,5	35,0	58,2	51,5	46,1	45,1	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	
Adjusted vitamin C (mg)		46,3	44,4	8,6	5,7	20,7	13,2	27,4	26,0	40,3	41,3	31,4	35,2	
		Age group: 45 to 54,9 years (N=61)												
		N=11		N=19		N=8		N=16		N=7		N=61		
Vitamin A (RE)	1000	889,3	598,5	541,7a	395,0	828,4	632,0	629,8	390,3	1379a	1188	761,2	632,9	a*
Adjusted vitamin A (RE)		943,8	1183	337,0	661,4	886,8	1397	405,2	549,3	3246	5283	870	2065	
Vitamin E (mg)	10	10,52	4,54	7,51	4,53	6,44	3,22	11,89	7,77	13,7	6,46	9,78	6,02	
Thiamin (mg)	1,5	1,17	0,48	1,18	0,48	1,01	0,35	1,27	0,39	1,17	0,36	1,18	0,42	
Riboflavin (mg)	1,7	1,73	1,02	1,56	0,56	1,51	0,69	1,63	0,50	1,72	0,69	1,62	0,66	
Niacin (mg)	19	16,31	7,78	10,23a	5,07	14,4	5,62	16,9a	4,82	17,50	7,35	14,46	6,45	a**
Vitamin B6 (mg)	2,0	1,16	0,52	0,75	0,30	0,96	0,36	0,99	0,38	1,20	0,19	0,96	0,39	
Vitamin B12 (ug)	2,0	5,67	4,45	4,72	3,36	6,54	5,59	4,59	3,32	9,20	7,01	5,61	4,49	
Folic acid (ug)	200	255,1	99,1	195,6	93,3	195,1	75,9	200,6	85,0	231,0	78,5	211,6	88,8	
Vitamin C (mg)	60	83,7	153,9	19,8	10,7	15,9	7,9	26,9	24,8	48,7	18,5	36,0	69,1	
Adjusted vitamin C (mg)		66,5	140,4	11,6	7,2	8,9	5,2	16,8	18,0	31,8	13,6	25,0	61,9	
		Age group: 55 to 64,9 years (N=39)												
		N=14		N=8		N=6		N=9		N=2		N=39		
Vitamin A (RE)	1000	700,4	748,2	519,6	245,8	527,8	265,7	952,6	1072,3	1032	191,6	712,0	698,0	
Adjusted vitamin A (RE)		910,5	1750	212,4	171,7	225,0	203,5	2020,5	4914,3	831,5	350,0	914	2571	
Vitamin E (mg)	10	9,39	3,71	5,68	2,69	10,06	7,21	9,60	6,37	9,60	5,52	8,79	4,98	
Thiamin (mg)	1,5	1,22	0,64	1,04	0,42	1,17	0,60	1,26	0,62	1,21	0,43	1,18	0,56	

Nutrient		Stratum of urbanisation												
		R		F		IS		MCU		UCU		Entire sample		P-value
	¶RDA	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	*SD	
Riboflavin (mg)	1,7	1,22	0,78	1,37	0,50	1,49	0,79	1,80	0,61	1,96	1,26	1,46	0,72	
Niacin (mg)	19	14,9	8,4	10,3	4,18	15,73	6,87	18,8	7,32	16,05	3,46	15,1	7,3	
Vitamin B6 (mg)	2,0	1,04	0,65	0,71	0,25	1,03	0,56	1,20	0,58	1,22	0,19	1,02	0,55	
Vitamin B12 (ug)	2,0	4,85	5,28	3,18	1,70	3,75	1,97	8,72	9,15	6,95	5,02	5,34	5,76	
Folic acid (ug)	200	224,3	116,6	169,9	70,5	213,2	108,7	229,1	97,1	262,5	57,3	214,5	99,1	
Vitamin C (mg)	60	40,9	45,2	19,9	9,8	24,8	14,3	22,7	12,5	79,5	21,9	31,9	31,6	
Adjusted vitamin C (mg)	60	27,8	34,4	11,6	6,4	15,0	9,5	13,5	8,4	55,2	17,2	21,0	23,7	

*P<0,05; **P<0,01; ***P<0,001; ¶RDA: Recommended dietary allowance; † Standard deviation; a, b, c, d: strata for which mean intakes differ significantly; Stratum of urbanisation: R=rural, F=farm; IS=informal settlement, MCU=middle class urban, UCU=upper class urban

8.2.6.1

Fat-soluble vitamins

For the females, mean reported vitamin A intakes were close to, or above, the RDA in most subgroups. The exceptions were the rural 25 to 34,9-year age group and the farm 35 to 44,9-year and 45 to 54,9-year age groups where the reported mean intakes fell below 67% of the RDA (536 RE). None of the differences between mean intakes were significant ($P > 0,05$). By contrast, there were several significant differences in reported mean vitamin A intakes among the various subgroups for the males. In the youngest age group, the reported mean intake of the middle class urban subjects was significantly higher than that of the farm subjects ($P < 0,05$) while in the 25 to 34,9-year and the 45 to 54,9-year age group the mean intake of the upper class urban stratum was significantly higher than that of the farm stratum. The reported mean intakes of vitamin A fell below 67% RDA (670 RE) for all age groups in the farm stratum. Other subgroups with mean intakes indicative of a risk of deficiency were the rural 15 to 24,9-year and 55 to 64,9-year age groups, the informal settlement 15 to 24,9-year, 25 to 34,9-year and 55 to 64,9-year age group and the middle class urban 35 to 44,9-year age group. Figures 8.13 and 8.14 show the distribution of subjects at risk of vitamin A deficiency according to age group in the various strata of urbanisation.

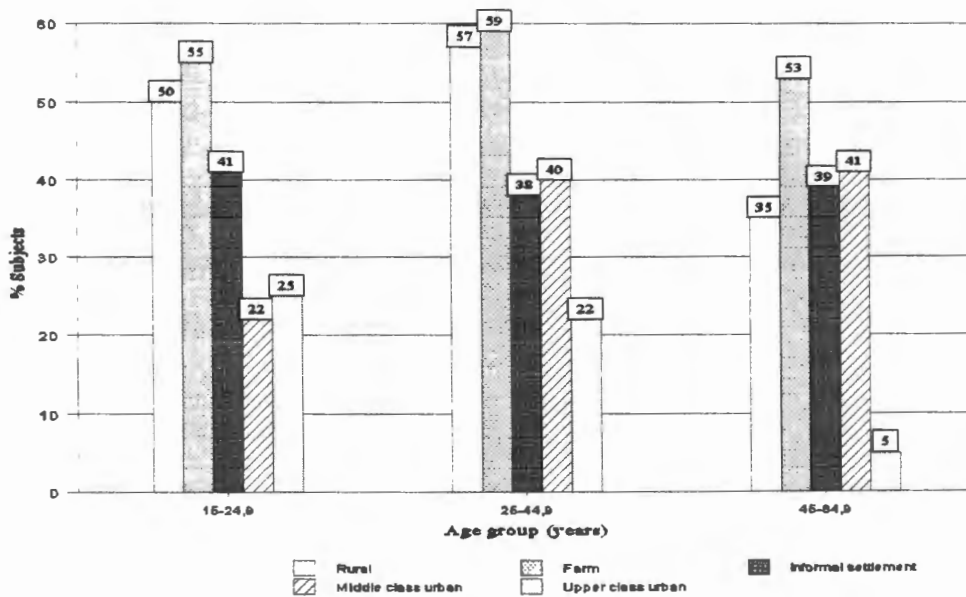


Figure 8.13: Percentage females with vitamin A intakes below 67% RDA according to age group and stratum of urbanisation (N=552)

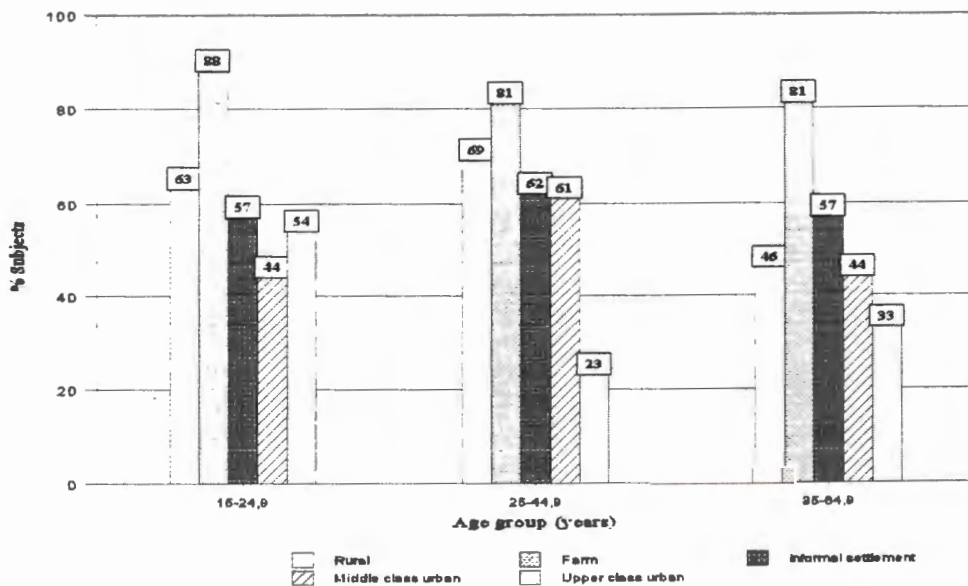


Figure 8.14: Percentage males with vitamin A intakes below 67% RDA according to age group and stratum of urbanisation (N=338)

Although there were no significant differences among the reported mean intakes of the strata of urbanisation for the females, a significantly higher percentage of subjects in the rural and farm strata in the age group of 24 to 44,9-years had intakes below 67% of the RDA than in the upper class urban stratum, where only 22% had alarmingly low intakes ($P<0,01$). In the eldest age group, only 5% of subjects had intakes below 67% RDA, a significantly lower percentage than the percentages of the farm, informal settlement and middle class urban strata ($P<0,01$).

More than 80% of the males in the farm stratum were at risk of a vitamin A deficiency. The upper class urban stratum again had the lowest percentages of subjects at risk in the age groups above 25 years, while the middle class urban stratum had the lowest percentage at risk in the youngest age group. Only the differences in percentages at risk between the upper class urban stratum and the rural, farm and middle class urban strata were significant for the 25 to 44,9-year age group ($P<0,01$).

When reported vitamin A intakes were adjusted for proportional and constant bias, similar increases in high intakes and decreases in low intakes occurred as seen with the other nutrients. Like calcium, vitamin A intakes showed a very high degree of variation, with intakes varying from less than 20 RE to more than 6000 RE per day. The coefficient of variation for the entire sample was 92%. This high degree of variation could account for the large differences between the reported and the adjusted mean intakes.

Regarding vitamin E, mean reported intakes appeared adequate across all strata and age groups. The only subgroup to report a mean intake of vitamin E below 6,7 mg (67% of the RDA) was the farm worker male stratum between 55 and 64,9 years of age (5,68 mg). There was a significant difference between the mean intake of the middle class urban male subjects and the males of the farm stratum in the 25 to 34,9-year age group ($P<0,05$).

The highest percentages of subjects at risk of a vitamin E deficiency were in the 45 to 64,9-year age groups of both the female (54%) and male (74%) farm strata and the 25 to 44,9-year age group of the male farm stratum (54%). Among the females, the percentage subjects at risk in the 15 to 34,9-year farm stratum was 36%, in the informal settlement 25 to 44,9-year and 45 to 64,9-year age groups the percentages were 33 and 39 respectively. Percentages in all the other strata

were below 25%. There were no significant differences in percentages between strata in any of the age groups ($P>0,05$). Among the males, the percentages of subjects at risk in the farm stratum in the 25 to 44,9-year age group (54%) were significantly higher than that of the rural (11%), the informal settlement (23%), the middle class urban (11%) and the upper class urban (20%) strata ($P<0,01$). Also, in the age group older than 45 years, the percentage of farm worker males at risk (74%) was significantly higher than rural males (21%), middle class urban males (28%) and upper class urban males (22%) ($P<0,01$).

8.2.6.2 Water-soluble vitamins

There are two outstanding features of the reported mean intakes of the water-soluble vitamins (Tables 8.14 and 8.15). First, the mean intakes of niacin, vitamin B6 and vitamin C of the farm stratum of both the males and females in all age groups (except for niacin in the female 25 to 34,9-year age group) fell below 67% of the RDAs (10,1 mg and 12,7 mg, 1,1 mg and 1,3 mg and 40 mg for niacin, vitamin B6 and vitamin C respectively). Also, the mean reported intakes of vitamin B6 were deficient in all age groups of the males in the rural stratum, but only in the 35 to 44,9-year age group of the rural females. Second, most of the significant differences occur between the farm stratum and the middle class and upper class urban strata. For example, the mean reported niacin intake of the upper class urban subjects is significantly higher than that of the farm subjects in the female 15 to 24,9-year age group, and in the male 15 to 24,9-year and 25 to 34,9-year age group while that of the middle class urban subjects is significantly higher in the 45 to 54,9-year age group.

Another notable feature is that of the very high variability of vitamin C intakes. In some subgroups the coefficient of variation exceeds 100%. Variability was lower among the farm workers, possibly, because the access to fruit was limited, while in the other strata, fruit was more readily available. Seasonal and geographic differences could also account for the variations in intakes. Interviews were conducted in the Rustenberg area (a rich citrus growing area) for some of the middle class and upper class strata during the citrus season (April to September), while the farms, which were not in a rich citrus area, were visited in February and March. Adjustment for constant and proportional bias resulted in lower mean intakes for all groups. Again, this could be accounted for the high degree of variability and the wide confidence intervals

for α_Q and β_Q (Tables 7.21 and 7.22).

The percentage distribution of females and males with reported intakes of niacin and vitamin C below 67% of the RDA are shown in Figures 8.15 to 8.18.

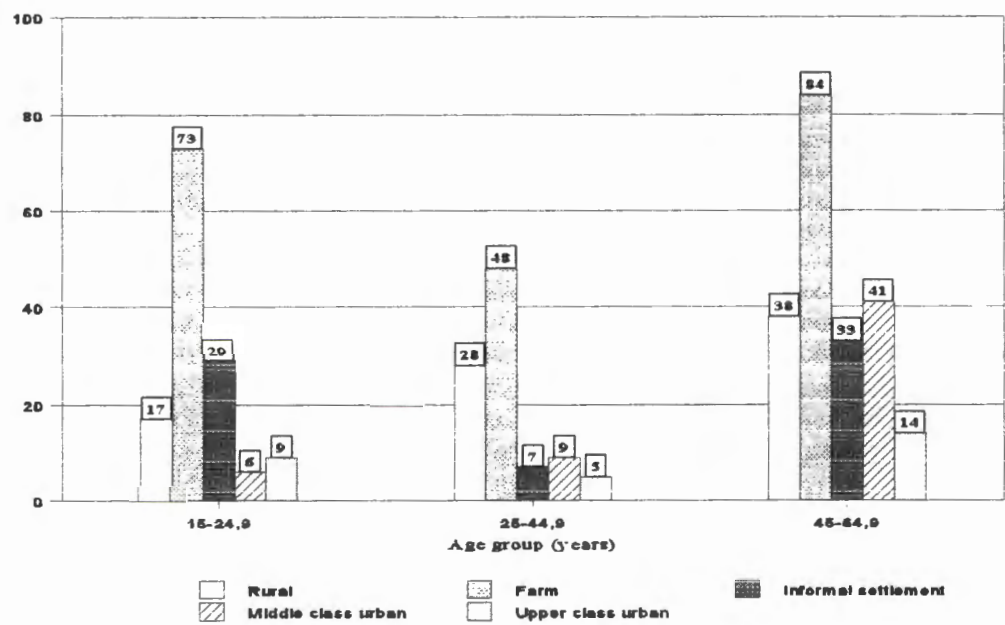


Figure 8.15: Percentage females with niacin intakes below 67% RDA according to age group and stratum of urbanisation (N=552)

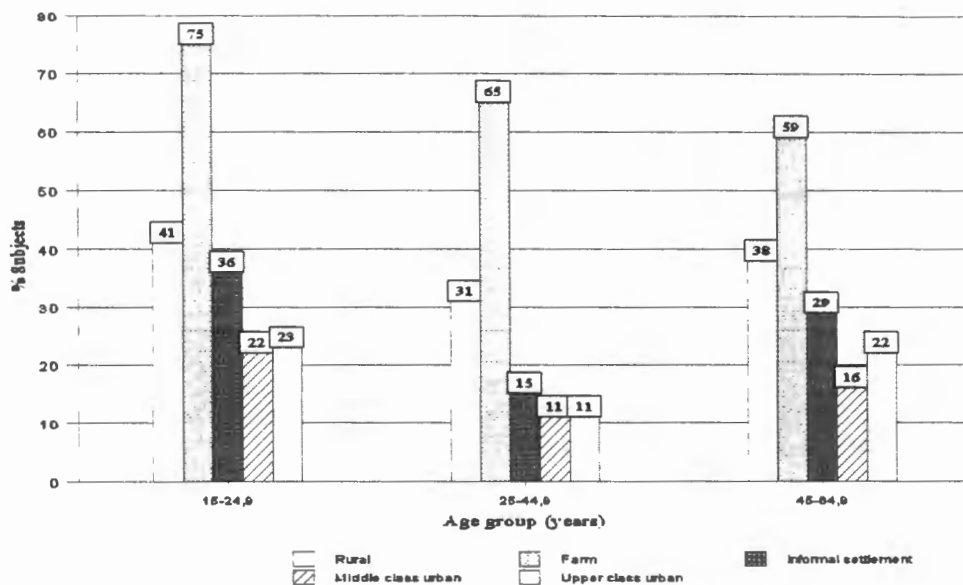


Figure 8.16: Percentage males with niacin intakes below 67% RDA according to age group and stratum of urbanisation (N=338).

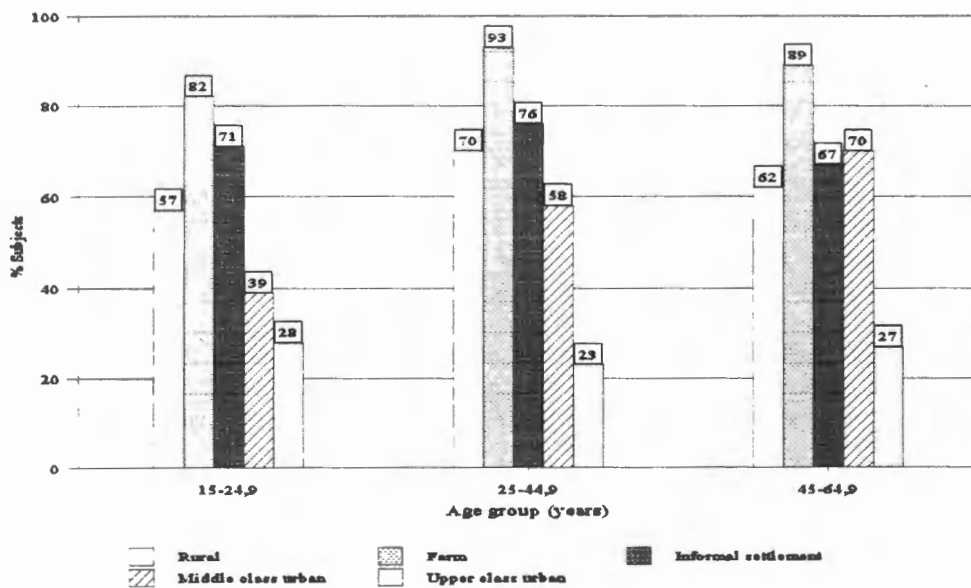


Figure 8.17: Percentage females with vitamin C intakes below 67% RDA according to age group and stratum of urbanisation (N=552).

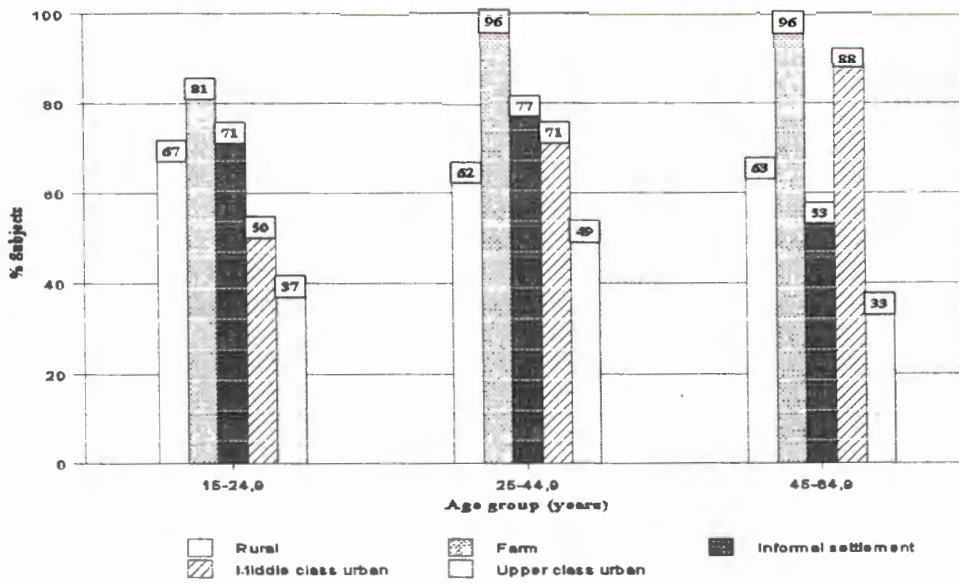


Figure 8.18: Percentage males with vitamin C intakes below 67% RDA according to age group and stratum of urbanisation (N=338)

The percentages of subjects with niacin intakes which put them at risk of a deficiency reflect the mean intakes of the strata. Most obvious is the high percentage of farm workers, both females and males, with risk of niacin deficiency compared to the low percentages in the other strata. Among the females, the percentage of subjects at risk is significantly higher for the farm workers than for the rural subjects in the 15 to 25-year age group, and the informal settlement, middle class urban and upper class urban subjects in the age group older than 45 years ($P < 0.01$). For the males, the differences in percentages at risk between the farm stratum and the middle class and upper class urban strata in the 15 to 24.9-year age group, between the farm and rural, informal settlement, middle class urban and upper class urban strata in the 25 to 44.9-year age group and between the farm and middle class urban strata in the 45 to 64.9-year age group, were significant ($P < 0.01$).

For vitamin C, almost all the male subjects over 25 years of age in the farm strata were at risk of a vitamin C deficiency. Significant differences occurred between the rural and upper class urban strata, and the farm and upper class urban strata in the 25 to 44.9-year age group ($P < 0.01$) in the females. Among the males, the differences between the percentages of subjects below 67% RDA in the 25 to 34.9-year age group between the farm and upper class urban strata; in the 25 to 44.9-year age group between the farm and rural, middle class and upper class urban strata and in the 45 to 64.9-year age

group between the rural and the farm and informal settlement strata, and between the farm and upper class urban strata were significant ($P<0,01$). Also significant in the eldest male age group was the difference between the middle and upper class urban strata ($P<0,01$).

Although only the graphs for niacin and vitamin C are shown, intakes of the other water-soluble vitamins showed similar patterns. The percentages of subjects with intakes of the B-complex vitamins below 67% RDA are summarised in Table 8.16.

Table 8.16: Percentage subjects with vitamin B complex intakes below 67% RDA (N=890).

*Stratum of urbanisation										
Vitamin	R (N=231)		F (N=128)		IS (N=121)		MCU (N=213)		UCU (N=197)	
	M %	F %	M %	F %	M %	F %	M %	F %	M %	F %
Thiamin	32	37	46	32	39	17	30	15	23	14
Riboflavin	41	17	35	25	24	16	10	15	15	5
Folic acid	17	14	39	24	17	16	8	11	9	7
Vitamin B6	68	63	94	83	66	46	59	46	44	24

*Stratum of urbanisation: R=rural; F=farm; IS=informal settlement; MCU=middle class urban; UCU=upper class urban

8.2.7 Differences in mean reported intakes between genders and age groups

The preceding results have concentrated on differences in intakes among strata of urbanisation within gender and age groups. However, from examination of the results, males appear to have lower mean reported intakes and higher percentages of subjects at nutritional risk than the females. The comparison of mean intakes of males and females, expressed as percentages of the RDA's, confirm this perception. With the exception of total energy, calcium, iron and folic acid, the nutrient intakes of the females were significantly higher than those of the males ($P<0,01$). For iron, the percentage of the RDA was higher for males than for females ($P<0,001$), probably due to the lower requirement for males.

With regard to differences in percentage RDA intakes among age groups (combined for gender and stratum of urbanisation), the most notable was the significantly higher protein and fat intakes of the

age group of 15 to 24,9-years than those of the age groups older than 35 years of age ($P<0,01$). By contrast, the mean percentage RDA for calcium of the youngest age group (42,3% SD=22,9) was significantly lower than those of the other age groups (60% SD=33).

8.2.8 Food intakes

8.2.8.1 Most frequently consumed foods

The analysis of nutrient and energy intakes provides the nutritionist with valuable information. For non-nutritionists, however, the expression of intakes in terms of foods or food groups is far more meaningful and easier to interpret. Therefore, the following section presents a summary of food intakes for the various strata of urbanisation. For simplicity, the strata of urbanisation have been divided only into genders and not into age groups as done with the nutrient intakes. Table 8.17 summarises the 10 foods consumed in the greatest amounts per person per day in each stratum for females and Table 8.18 for the males.

Table 8.17: Females: 10 Foods consumed in largest amounts per person per day (N=552)

†Stratum of urbanisation										
	R (N=153)		F (N=59)		IS (N=80)		MCU (N=142)		UCU (N=118)	
Rank	Food	*Ave g	Food	Ave g	Food	Ave g	Food	Ave g	Food	Ave g
1	Tea	380	Tea	438	Tea	413	Tea	413	Tea	283
2	§Milk	153	Milk	362	Sorghum beer	135	Milk	133	Milk	148
3	**Maize meal	122	**Maize meal	170	Milk	134	**Maize meal	90	Car cold drink	74
4	Sorghum beer	61	Sorghum beer	141	**Maize meal	112	Car cold drink	81	Apple	69
5	Brown bread	56	Dil cold drink	68	Apple	69	Apple	58	Dil cold drink	59
6	Coffee	43	Coffee	67	Coffee	60	¶Red meat	51	¶Red meat	59
7	¶Red meat	37	Sugar	33	Dil cold drink	51	Brown bread	51	**Maize meal	55
8	Sugar	36	Corn-on-cob	31	¶Red meat	50	Sorghum beer	50	Rice	51
9	Apple	32	Mageu	31	Rice	46	Coffee	47	Coffee	50
10	Sorghum meal	32	White bread	28	White bread	37	Orange	41	Orange	43

Ave: average intakes per person per day; **Maize meal: raw maize meal; ¶Red meat: includes all cuts of beef, mutton and pork and processed meats; §Milk: fresh whole milk; Dil: diluted cold drinks; Car: carbonated cold drink; †Stratum of urbanisation: R=rural, F=farm, IS=informal settlement, MCU=middle class urban, UCU=upper class urban

Table 8.18: Males: 10 Foods consumed in largest amounts per person per day (N=338)

†Stratum of urbanisation										
	R (N=78)		F (N=69)		IS (N=41)		MCU (N=71)		UCU (N=79)	
Rank	Food	*Ave g	Food	Ave g	Food	Ave g	Food	Ave g	Food	Ave g
1	Tea	346	Milk	375	Commercial beer	286	Tea	317	Commercial beer	237
2	Milk	158	Tea	364	Tea	270	Commercial beer	268	Tea	168
3	Sorghum beer	137	Sorghum beer	355	Sorghum beer	221	Milk	188	Milk	142
4	**Maize meal	136	*Maize meal	210	Milk	180	**Maize meal	146	Car cold drink	96
5	Commercial beer	135	Commercial beer	63	**Maize meal	111	Sorghum beer	118	**Maize meal	85
6	Brown bread	96	Dil cold drink	48	Dil cold drink	92	Car cold drink	100	†Red meat	82
7	Coffee	92	Sugar	36	Mageu	43	Brown bread	62	Dil cold drink	64
8	Cold drink	63	Car cold drink	34	White bread	40	Apple	53	Rice	51
9	†Red meat	48	Corn-on-cob	31	Brown bread	40	Rice	50	Brown bread	57
10	Apple	40	Samp	28	†Red meat	35	†Red meat	41	Coffee	54

*Ave: average intakes per person per day; **Maize meal: raw maize meal; †Red meat: includes all cuts of beef, mutton and pork and processed meats; §Milk: fresh whole milk; Dil: diluted cold drinks; Car: carbonated cold drink; †Stratum of urbanisation: R=rural, F=farm, IS=informal settlement, MCU=middle class urban, UCU=upper class urban

The above two tables show the foods consumed in the largest quantities in terms of mass by the subjects in the different strata. In the case of the females, the two foods consumed in the largest amounts in all strata were tea and milk. Of note is that the subjects in the farm strata consumed more than double the amounts of milk than those from the other four strata. This was because farm workers received a daily milk ration. Maize meal, expressed as dry meal, was the third largest quantity of food consumed in all strata except the upper class urban strata. If this was converted to cooked porridge, the amounts consumed would be the largest in terms of quantity (the average conversion factor is dry weight maize meal x 3). In the upper class stratum maize meal dropped to seventh place. Apart from milk, protein rich foods appear low on the list for the rural and informal settlement strata and do not appear at all for the farm stratum. In the middle and upper class urban strata, red meat was the food consumed in the sixth largest amount. The only fruits to appear on the list for the rural and informal settlement strata are apples, while apples and oranges appear within the first 10 foods for the middle and upper class urban subjects.

The most noticeable difference between the males and females in terms of quantities of foods consumed is that both sorghum beer and commercial beer are consumed in large amounts by the males across all strata. Milk was consumed in the largest amounts by the farm worker stratum. Maize meal was also consumed in large amounts by subjects in all strata, but in the largest amount by the farm workers, and in less than half this amount by the upper class urban stratum. Another difference in the food consumption pattern between strata is that there is a large drop in the quantities of foods consumed in the top four and lower six foods in the rural and farm strata while quantities decrease more evenly in the other strata. This may be explained by the differences in the numbers and varieties of foods consumed in the different strata. Figure 8.19 shows that the subjects in the farm worker stratum consumed significantly fewer types of foods than any of the other strata ($P<0,001$) while the subjects in the upper class urban stratum consumed significantly more types of foods than subjects in all the other strata ($P<0,001$). There was no significant difference in the variety of foods consumed by the rural and informal settlement subjects ($P>0,05$), but the middle class urban subjects consumed significantly more types of foods than the rural subjects ($P<0,05$).

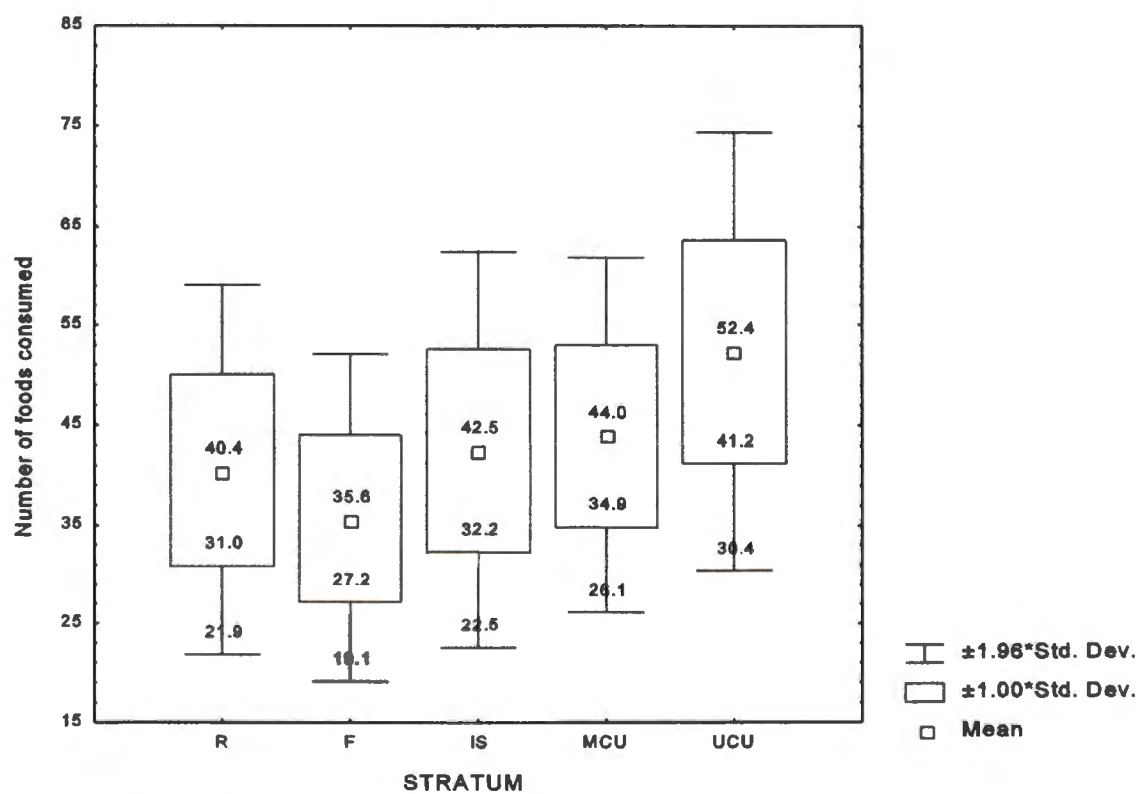


Figure 8.19: Mean and standard deviation of number of foods consumed per person according to stratum of urbanisation

Subjects living in the urban areas, especially those in the upper class stratum, had access to a wider variety of foods and preparation methods. This could be seen from the responses to the questions regarding meals eaten away from home. In the upper class urban stratum, 48% of the subjects ate a meal away from home more than once a month, compared to 38% middle class urban subjects and 26% each of the rural, farm and informal settlement subjects. In addition, the majority of upper class urban subjects (60%) ate these meals at restaurants or steak houses or bought meals from take-away outlets such as Kentucky Fried Chicken. On the other hand, most of the subjects who ate meals away from home from the other strata (81%, 91% 69% and 50% for the rural, farm informal settlement and middle class urban strata respectively) obtained meals from 'cafes' or 'Spazas'. These meals usually consisted of stiff maize meal porridge and meat or chicken stew or sauce, that is, they were very similar to a home prepared meal.

8.2.8.2 Percentage energy intake provided by food groups

To take differences in total energy intake into account, the Tables 8.19 and 8.20 present intakes in terms of the percentage of total energy provided by food groups for females and males respectively. The 'food groups' used to present the results are groupings into categories of similar foods in order to show differences between strata (for classification of foods into groups see 5.7.3 and Table 5.3). At the end of this section, the food intakes will be summarised in terms of the 'Basic five food groups' and compared to the recommendations of the South African Department of Health Services and Welfare (1992).

Table 8.19: Females: Mean percentage energy provided by food groups (N=552).

‡Stratum of urbanisation											P-value
Food group	R (N=153)		F (N=59)		IS (N=80)		MCU (N=142)		UCU (N=118)		
	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	
Milk	7,6a	0,6	12,8abcd	9,3	5,9b	5,4	7,2c	6,2	7,5d	5,5	a,b,c,d***
Meat and meat substitutes											
Red meat	7,4ae	5,9	5,5abcd f	5,0	10,6bg	6,4	11,6ch	7,3	17,8d efgh	8,5	a-h***
Chicken	2,6	2,2	2,6	3,3	3,1	2,9	3,3	2,7	3,0	2,1	
Fish	0,7ab	1,0	0,8a	1,5	1,1	1,5	1,3b	1,5	1,6a	1,6	a,b**
Egg	3,6a	3,8	1,8a	2,3	3,2	4,8	3,1	3,3	2,9	2,7	a*
Legumes	3,5	3,5	3,0	4,2	2,7	3,2	3,4	3,2	3,0	2,8	
TOTAL	17,8		13,7		22,7		22,7		28,3		

‡Stratum of urbanisation											
Food group	R (N=153) Mean †SD		F (N=59) Mean †SD		IS (N=80) Mean †SD		MCU (N=142) Mean †SD		UCU (N=118) Mean †SD		P-value
Bread and cereals											
Maize meal	24,0 ^{ae}	14,7	34,8 ^{abcd f}	15,8	22,5 ^{bg}	15,9	19,2 ^{ch}	14,7	10,0 ^{d efgh}	8,8	a-h***
Bread	9,4 ^a	7,6	5,4 ^{ab}	4,5	8,5	6,3	9,4 ^b	6,3	8,4 ^a	5,5	a,b**
Rice	2,2 ^a	2,3	1,8 ^{ab}	2,2	3,1 ^b	2,9	2,6	2,2	3,1 ^a	3,2	a,b*
Samp	1,5	1,9	1,0	1,1	1,3	1,9	1,6	2,0	1,1	1,5	
¶Other cereals	11,8	4,7	6,6	3,9	8,7	5,2	11,0	5,6	10,2	5,0	
TOTAL	48,9		49,6		44,1		43,8		32,9		
Fruit and vegetables											
Fruit	3,3 ^a	3,5	1,0 ^b	1,0	4,1 ^c	3,7	4,7 ^d	4,3	6,7 ^{abcd}	5,0	a-d***
Vegetables	2,9	2,6	3,6	3,0	2,9	3,1	3,0	2,5	3,7	2,3	
Potatoes	2,2	2,3	2,2	2,4	3,1	4,7	2,5	2,2	1,9	1,5	
TOTAL	8,4		6,8		10,1		10,2		12,3		
Fat	4,7	3,2	3,9	3,2	5,2	3,8	5,6	3,9	5,0	4,1	
Miscellaneous											
Sugar	7,2	6,2	7,9	7,8	6,7	5,6	6,1	5,5	5,8	4,7	
Sweets & cakes	1,0	1,7	0,5 ^a	1,2	1,2	2,1	1,1	2,0	1,9 ^a	4,2	a*
Cold drinks	0,9 ^{ab}	2,5	0,5 ^{ab}	1,3	1,3	1,8 ³	2,0 ^a	2,9	2,3 ^b	2,9	a,b*
Alcoholic drinks	1,8	6,1	3,1	7,8	3,3	12,1	1,8	3,8	0,6	2,4	
TOTAL	10,9		12,0		12,5		11,0		10,6		

‡Stratum of urbanisation: R=rural, F=farm, IS=informal settlement, MCU=middle class urban, UCU=upper class urban
†SD: Standard deviation; a - h: significant differences between pairs of strata; Level of significance: *P<0,05; **P<0,01; ***P<0,001

Table 8.20: Males: Mean percentage energy provided by food groups (N=338).

‡Stratum of urbanisation											
Food group	R Mean †SD		F Mean †SD		IS Mean †SD		MCU Mean †SD		UCU Mean †SD		
Milk	5,8 ^a	5,6	12,6 ^{abcd}	8,8	7,1 ^b	5,0	6,1 ^c	4,8	5,7 ^d	4,1	a-d***
Meat and meat substitute											
Red meat	8,9 ^{ae}	5,7	4,7 ^{abedf}	4,6	10,9 ^{bg}	8,0	11,0 ^{ch}	7,0	16,8 ^{d efgh}	9,3	a-h***
Chicken	2,7	2,4	2,0	2,0	2,4	2,1	2,9	2,5	2,8	2,4	
Fish	1,5	1,9	0,8	1,3	1,3	1,6	1,1	1,2	1,3	1,3	
Egg	4,1	4,3	2,6	3,4	4,6	4,6	3,5	3,9	4,2	4,0	

‡Stratum of urbanisation										
Food group	R		F		IS		MCU		UCU	
	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD	Mean	†SD
Legumes	2,9	2,6	3,0	4,9	3,2	3,6	3,3	3,4	3,2	2,9
TOTAL	20,1		13,1		22,4		21,8		28,3	
Bread and cereals										
Maize meal	23,1ae	17,1	36,4abcdf	18,4	21,2bg	12,8	23,7ch	15,0	14,6d efgh	10,1
Bread	11,9a	9,3	5,6ab	6,5	9,1	6,8	8,9	6,1	9,3b	5,2
Rice	2,0	1,8	1,6a	2,1	2,3	1,9	2,5	3,4	2,8a	2,4
Samp	1,3	1,6	1,4	2,1	0,8	0,9	0,8	1,0	0,8	1,0
¶Other cereals	9,9	8,9	4,6	4,0	7,4	5,2	6,8	6,1	9,4	4,7
TOTAL	48,2		49,6		40,8		42,7		36,9	
Fruit and vegetables										
Fruit	3,3ae	3,3	1,5abcdf	1,3	3,3bg	2,6	2,9ch	2,6	5,3aefgh	4,1
Vegetables	2,5	2,0	2,6	1,9	2,0	1,8	2,2	1,7	2,6	1,8
Potatoes	2,7	2,8	1,4	1,4	2,5	2,3	2,6	2,9	2,3	2,1
TOTAL	8,5		5,5		7,8		7,7		10,2	
Fat	4,5	3,4	2,9ab	2,4	4,0	3,3	4,9a	4,1	4,5b	2,9
Miscellaneous										
Sugar	5,5a	5,6	7,6abcd	7,2	5,9b	4,9	5,5c	5,8	4,3d	4,4
Sweets & cakes	0,7	1,0	0,4a	0,8	0,7	1,3	1,4a	2,8	1,2	1,7
Cold drinks	1,4b	1,8	0,7a	2,3	1,2	1,6	1,8	2,5	2,4ab	2,9
Alcoholic drinks	4,0	8,5	7,0	10,0	9,0	12,4	7,0	11,2	4,5	7,7
TOTAL	11,6		15,7		16,8		15,7		12,4	

‡Stratum of urbanisation: R—rural, F—farm, IS—informal settlement, MCU—middle class urban, UCU—upper class urban

†SD: Standard deviation; a - h: significant differences between pairs of strata; Level of significance: *P<0,05; **P<0,01; ***P<0,001

The above tables show that significant differences exist in approximately half the food groups for both males (10 of 19) and females (10 of 19). The food groups which show no significant differences among strata of urbanisation are chicken, legumes, samp, other cereals, vegetables, potatoes, and alcoholic drinks for both males and females; fish and eggs for males and fat and sugar for the females ($P>0,05$).

It is clear from Table 8.19 and 8.20 that few significant differences exist among the rural, informal settlement and middle class urban strata. For example, among the females the percentage of energy provided by fish in the middle-class urban stratum was significantly higher than that of fish in the rural stratum ($P<0,05$). Most differences occurred between the farm stratum and the upper-class urban

stratum and the other three strata, with the pattern of differences being similar for males and females.

(a) Milk group

The mean milk intake in the farm stratum was significantly higher than in the other four strata ($P < 0.001$), mainly due to the provision of milk to the farm workers. In the other strata, milk was usually consumed only in tea or coffee. Most milk used in all strata was fresh, full cream milk. Yoghurt made a small contribution to the milk intake especially of the female subjects. The consumption of cheese was minimal in all strata.

(b) Meat and meat substitutes

For red meat, the energy contribution to the diet of the upper class urban subjects was significantly higher than for the other four strata ($P < 0.001$), while that of the farm worker stratum was significantly lower than that of all four other strata ($P < 0.001$). Also, there was a marked increase in red meat intakes with increasing level of urbanisation. The mean red meat intake of the upper class urban subjects was more than three times that of the farm worker stratum and double that of the rural stratum. This may reflect both increased availability of meat in the urban areas (informal settlement and middle-class urban strata showed increases, but these were not significant) as well as the increased affluence of the subjects in the upper class urban stratum. Interestingly, chicken intakes did not differ significantly among strata.

The type of fish eaten differed between strata. In the rural and farm worker strata, most of the fish eaten were canned pilchards, usually mixed with tomato and onions (see Chapter 3). In the urban strata, fried fish, both home-prepared and commercial, became more popular.

(c) Bread and cereals

In marked contrast to the meat intake, the energy contribution of maize meal was significantly higher for the farm worker stratum and lower for the upper class urban stratum than the other strata. Not only did the amount of maize meal differ significantly among strata, but also the type of maize meal. Most commercially available maize meal is enriched with niacin and riboflavin, while the maize meal

provided by the farmers directly from the mills is not. Samp is not enriched with vitamins. This difference is seen in Figures 8.15 and 8.16 with the high percentages of subjects with niacin and riboflavin intakes below 67% RDA. Figure 8.20 shows the proportions of enriched and unenriched maize (meal and samp) consumed by the different strata.

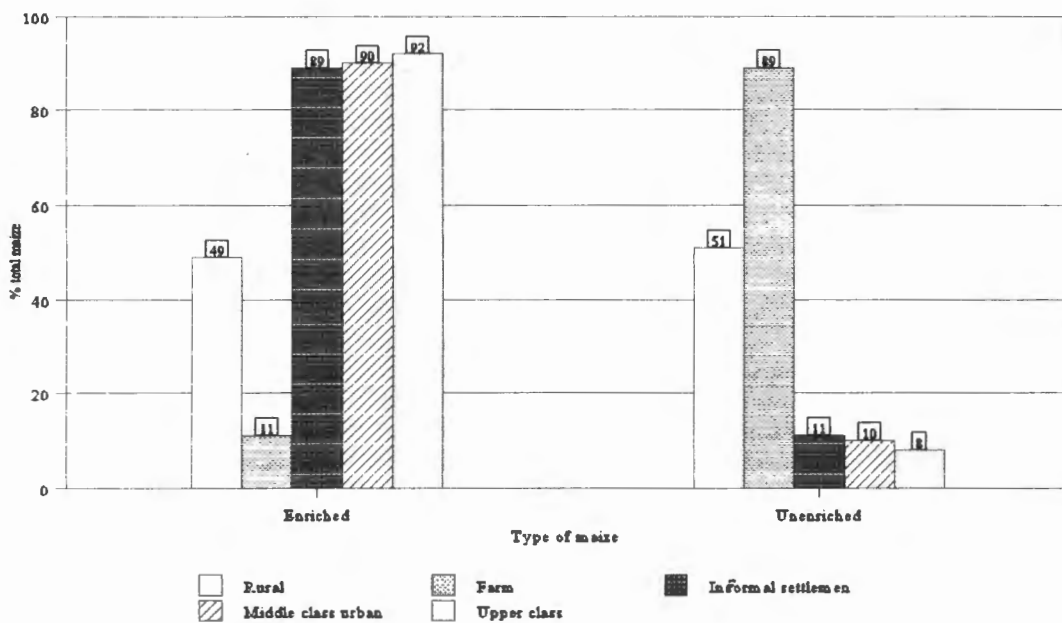


Figure 8.20: Proportions of enriched and unenriched maize products consumed according to stratum of urbanisation

In the rural stratum, approximately equal amounts of enriched and unenriched maize were used. Subjects obtained maize meal from both local mills (unenriched) as well as from nearby towns which supplied enriched commercial maize meal. In the farm stratum, 90% of the maize consumed was unenriched. In the informal settlement, middle class and upper class urban strata, almost all subjects used enriched maize meal. Unenriched maize was consumed mostly as samp.

Together with the overall decline in the amount of cereals consumed from the rural and farm strata to the urban strata, there was an increase in the variety of cereals consumed. In the rural, informal settlement and farm strata, maize was the predominant cereal, in the middle class urban stratum, maize remained the most frequently consumed cereal, but other cereals such as bread, rice, pastas and

breakfast cereals made an appearance. In the upper class urban stratum, maize was no longer the predominant cereal. Rather, there was a more even distribution among a wider variety of cereal foods.

There was a somewhat contradictory trend in the energy contribution of bread to the diet among strata of urbanisation. For both males and females, the farm worker stratum showed the lowest mean percentage of energy from bread, while the energy contribution of bread to the diets of the subjects in the informal settlement, middle class urban and upper class urban strata was similar. The percentage of energy provided by bread was, however, highest in the rural stratum. There were also differences in the type of bread (white or brown) consumed as shown by Figure 8.21.

In the farm areas, most of the bread consumed was home made using refined, white bread flour prepared either as 'dumpling' or 'fat cakes' (see Chapter 3). Commercial bread, both brown and white, was only readily available to the women who worked as domestic helpers. The reason for the trend of higher brown bread consumption in the rural areas and lower consumption in the informal settlements can only be speculated. 'Dumpling' and 'fat cakes' were popular in both areas. Possibly, brown bread was more readily available or cheaper than white bread in the rural areas, while in the informal settlements white bread was eaten more frequently. In the middle class and upper class strata, white and brown bread were consumed in almost equal amounts.

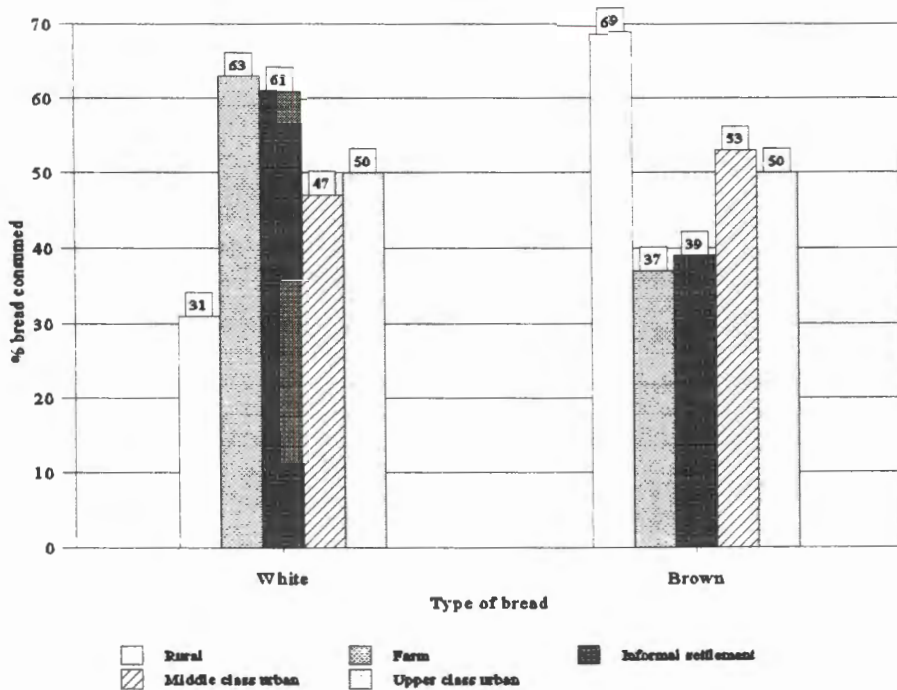


Figure 8.21 : Proportions of white and brown bread consumed according to stratum of urbanisation

(d) Fruit and vegetables

Mean fruit intakes showed more marked changes with level of urbanisation among the females than the males. The lowest intakes were in the rural and farm strata, but increased in the informal settlement, middle class and upper class urban strata. Among the males, mean fruit intake was lowest in the farms ($P < 0.01$) and highest in the upper class urban stratum ($P < 0.01$), with no significant differences between the rural, informal settlement and middle-class urban strata. Similarly to the findings of the preliminary study (Table 3.9), the most popular fruits in all strata were apples, oranges and bananas. Other fruit such as grapes and peaches were consumed mainly in the urban areas.

There were no significant differences in the proportion of energy provided by vegetables among the strata. From Tables 8.17 and 8.18, it can be seen that corn-on-the-cob ('green mealies') was among the 10 foods consumed in the largest quantities by the farm strata. This could have increased the percentage of energy provided by vegetables to a similar level to that of the other strata.

(e) Fat

The proportions of energy supplied by fat shown in Tables 8.19 and 8.20 represent fat used as spread on bread, salad dressings, cream or in the recipes developed specifically for the THUSA project (Chapter 3). Invisible fat and fat used in cooking of foods, the nutrient values for which were obtained from the Food Composition Tables (Langenhoven *et al.*, 1991a) are not included. The mean percentage of energy provided by added fat was lowest in the farm stratum and highest in the middle and upper class urban strata, but only the differences among the males were significant ($P < 0,05$). Vegetable oil was the most frequently used fat for cooking, ranging from 70% in the informal settlement stratum to 90% in the rural and upper class urban strata. Other fats used for cooking were hard vegetable fat (6,5%), margarine (20%) and 'dripping' (a mixture of fats) (4,3%).

(f) Sugar, sweets and drinks

The significantly higher intakes of sweets and cold drinks in the urban strata can be explained by both an increased availability and the means with which to purchase such items. From Table 8.17, diluted cold drinks appeared very popular in the farm and rural areas, yet the energy contribution was low. This is because most of these drinks are artificially sweetened and have a negligible energy content.

For the males, the proportion of energy provided by sugar was significantly higher in the farm worker stratum than in the other strata ($P < 0,05$). Since the diet of the subjects on the farms was very limited, sugar was a very important energy source as well as being easily available.

Alcoholic drinks provided a substantial percentage of the total energy content of the diet of the males, ranging from a mean of 4,0% in the rural stratum to 9,0% in the informal settlement stratum. The differences among strata were not statistically significant ($P > 0,05$). Obtaining accurate information on alcohol consumption was extremely difficult. Many subjects reported drinking 'two or three' cases (12 bottles) of 'quarts' (750 ml bottles) of beer over a weekend. Usually, men drink together, so it is difficult to know exactly how many bottles or cans were consumed by an individual. Also, the amount of 'home made' beer was very difficult to quantify. Thus, the amounts given in Tables 8.19 and 8.20 can be regarded only as approximations, and possibly underestimate the total alcohol intake.

8.2.8.3

Comparison of food intake to food group recommendations

The Department of Health Services and Welfare (1992) has published guidelines expressing food intake in terms of portions that are understandable to the lay population. The comparison of these recommendations to the food intake of the subjects in the present study are given in Table 8.21.

Table 8.21: Comparison of food group intake with recommendations*

Food group	*Recommended	†Stratum of urbanisation									
		R		F		IS		MCU		UCU	
		Mean	**SD	Mean	**SD	Mean	**SD	Mean	**SD	Mean	**SD
Males											
^a Milk	400 ml	200	250	400	275	225	175	250	225	200	150
^b Meat	2	2,4	1,2	1,6	1,2	2,6	1,7	2,7	1,5	3,2	1,5
^c Cereals and bread	4+	14,4	6,9	15,1	8,3	11,3	6,2	13,8	5,8	11,0	4,9
^d Fruit & vegetables	4+	3,5	2,6	2,4	1,9	2,8	1,8	3,5	2,5	4,1	2,5
^e Fat	3-8	1,9	1,3	1,2	1,0	1,6	1,3	2,6	2,5	2,0	1,2
Females											
^a Milk	400 ml	225	175	375	275	175	175	200	175	225	200
^b Meat	2	2,0	1,1	1,4	1,1	2,1	1,3	2,3	1,2	2,6	1,1
^c Cereals and bread	4+	13,1	5,8	12,9	6,8	11,6	5,9	10,9	5,6	8,8	4,3
^d Fruit & vegetables	4+	3,2	2,5	2,6	2,0	3,4	2,3	3,7	2,7	4,6	2,8
^e Fat	3-8	1,9	1,4	1,5	1,3	2,1	1,6	2,2	1,6	2,1	1,9

*Department of Health Services and Welfare (1992) **Standard deviation, †Stratum of urbanisation: R=rural, F=farm, IS=informal settlement, MCU=middle class urban, UCU=upper class urban

a: 1 portion=200 ml milk, 30 g cheese, 200 ml yoghurt

b: 1 meat portion=90 g cooked red meat, chicken or fish; 1 egg; 125 ml cooked legumes

c: 1 bread portion=30 g slice of bread or 125 ml cooked cereal, samp or pasta.

d: 1 Vegetable portion = 125 ml cooked vegetable; 1 fruit portion= 1 whole medium fruit

e: The recommended number of fat portions includes margarine, butter, vegetable oils and fat used for baking and cooking purposes, salad dressing, cream and bacon. The calculated number of fat portions includes fat used in the preparation of recipes derived for the present study (Chapter 3), but do not include fat from mixed dishes for which the MRC Food Composition Table values (Langenhoven *et al.*, 1991a) were used.

Comparison of the food intake of the sample with the recommendations of the Department of Health Services and Welfare (1992), show considerable differences. Only the subjects in the farm stratum came close to meeting the recommended daily intake of milk (400 ml), the mean milk intakes of the other strata were a half or less of the recommendation (The amounts of milk given in Table 8.22 are not the same as those in Tables 8.17 and 8.18, as those in the former table include other milk products

such as cheese, yoghurt and milk powder while those in the latter only include fresh, whole milk).

With regard to the intake of meat and meat substitutes, all strata, except the farm workers, fall within the recommendations, with the males of the upper class urban stratum achieving a mean intake slightly higher than that recommended. The most marked contrast between recommended number of portions and the number of portions consumed by the sample is in the cereal and bread group. Although the recommendations do not give a maximum number of portions, the number consumed by all strata is double or more that of the minimum four portions suggested. The greatest number of portions of bread and cereals were consumed by the rural and farm subjects while the lowest numbers were consumed by the upper class urban subjects. With regard to the consumption of fruit and vegetables, only the upper class urban subjects achieved the recommended minimum of four portions per day. Fat intakes in terms of portions appear low, but as already pointed out these do not include the total amount of fat consumed.

8.2.8.4 Wild fruits and animals

Provision was made on the QFFQ to record wild fruit, vegetables and animals eaten by the subjects. However, analysis of this data was difficult for the following reasons:

- (a) Quantities were very difficult to quantify. For example, subjects would say that they picked fruit here and there as they walked. This also applied to wild animals as the bird or animal would be shared among the group
- (b) Unless the fruit was actually in season at the time of the survey, the researcher had to rely on descriptions to identify the type of fruit.
- (c) Nutrient analyses are not available for most of the wild fruit growing in the North West area.

Analysis of the data, showed that little use was made of wild foods. The exception was a type of wild spinach, *thepe*, which was prepared and cooked in the same way as cultivated spinach (see Chapter 3), and was analysed as spinach. Only 11% of the subjects in the rural areas and 7% of those from the farms, mentioned eating wild fruit when it was available. Wild fruits were not mentioned by any subjects in the informal settlement, middle class or upper class urban strata. Wild animals (rabbits)

be a reflection of increased affordability and availability.

8.3.3 Energy and nutrient intakes

In the discussion of the food and nutrient intakes of the THUSA sample, the findings of the reproducibility and relative validation studies must be kept in mind. For this reason, the adjusted mean intakes were shown for energy and the nutrients for which the SEM procedure was used (Tables 8.9 to 8.15). Two points must be noted regarding the generalisation of the results of the reproducibility and relative validation studies to the total study sample. First, the subjects were all volunteers who were prepared to participate in further studies. Thus, they may have been more motivated and educated than the main sample in general and so might have responded more accurately to the QFFQ. Especially with regard to the relative validation sample, it must be remembered that the farm worker stratum was excluded because of the low literacy level of the group. Thus, the reproducibility and relative validity of the QFFQ in the entire sample may be lower than reflected in the results of the substudies. A second criticism of the study design was that the use of different interviewers may have affected the reliability of the results. As explained in the Chapter 5 (Methods) quality control measures of continual checking were used throughout the study in an attempt to keep interviewer effects to a minimum. Also, as seen from the results presented in Chapter 7 (7.3.4), good agreement was obtained between interviewers for energy and the macronutrients and moderate agreement was achieved for calcium, iron and vitamin A. Thus, although interviewer effects cannot be ruled out, the overall influence on the results may not have been too great.

8.3.3.1 Energy and macronutrients

The mean reported energy intakes of both males and females were higher than the mean intakes of African populations obtained from a meta-analysis of 24-hour recall data (Vorster *et al.*, 1997b) (see Chapter 2, Table 2.3). The results of the present study were similar to energy intakes derived from other methods of dietary assessment for females (9523 kJ and 8968 kJ for urban and rural females respectively) but were lower than those for males (12076 kJ and 10048 kJ for urban and rural males respectively) (Vorster *et al.*, 1997b). The highest percentages of subjects with energy intakes below 67% of the RDA were in the farm worker stratum, with the group with lowest energy intakes being the young males. From the results of the relative validation study (Chapter 7), the QFFQ appeared

to underestimate true energy intakes. This effect can be seen by the higher mean intakes after adjustment for constant and proportional bias. It cannot be assumed, however, that the reported energy intakes of all subgroups were underestimated. Low intakes actually appeared to be overestimated by the QFFQ. For example, the mean intakes of the 15 to 24,9 and the 45 to 54,9-year-old farm worker females and the 15 to 24,9 and 55 to 64,9-year-old farm worker and the 45 to 54,9 informal settlement males were lower after adjustment. The proportion of subjects at risk of deficient energy intakes may be overestimated for some of the subgroups, but the possibility that this proportion may be underestimated in others cannot be overlooked.

Reported mean protein intakes in all but three subgroups appeared adequate, both in comparison to the RDA and to results obtained from other South African studies (Vorster *et al.*, 1997b). The sources of protein, however, differed between strata. In the rural and farm worker strata, more than half the protein intake was derived from plant sources and was thus of low biological value. As the strata became more urbanised, the proportion of plant protein decreased. Although protein intakes generally appeared adequate, there is a risk in the rural and farm worker strata of a lack of essential amino acids in the diet of the population, especially if the intake of legumes and cereals was not balanced. Also, particularly in the farm worker stratum where energy intakes were low, part of the protein may be used as an energy source rather than for the maintenance of body tissues.

Mean reported total fat intakes for the rural and urban subjects (informal settlements, middle class urban and upper class urban strata) were within a similar range to those reported by Vorster *et al.* (1997b) for both rural and urban groups and by Gresse (1991) for urban subjects. The reported fat intakes of the farm worker stratum were low and resembled those reported for rural Vendas (35,8 g and 49,7 g for males and females respectively) (Vorster *et al.*, 1994). The highest mean fat intakes were reported for the upper class urban stratum. The effect of adjustment for bias on fat intakes increased the differences between the urban and the farm worker strata with the mean intakes of the urban strata increasing while those of the farm worker stratum decreased.

Although total carbohydrate intakes appeared higher in the rural and farm worker strata, there were no significant differences among strata in any age group for either the males or the females. This finding is in contrast to those reported by Vorster *et al.* (1997b) and Lubbe (1971) where carbohydrate intakes of rural subjects were approximately double those of urban subjects. The range

reported for the rural Venda (Vorster *et al.*, 1994) and of 15 to 22 mg reported for urban Africans (Gresse, 1991). The iron intakes of both the male and female farm workers were alarmingly low, with the lowest mean intake (4,7 mg for the women in the 45 to 54,9-year age group) being less than a third of the RDA. More than 75% and 60% of the females and males respectively were at risk of an iron deficiency. Adjustment of the intakes for bias further reduced low intakes while raising high intakes. Points of concern regarding iron intakes are that, for the females, a high proportion (greater than 44%) of subjects in all strata in the age groups younger than 45 years have intakes below 67% RDA. Second, reported intakes do not take account of bio-availability of the iron. Vorster *et al.* (1994) reported low haemoglobin levels (7,6 and 6,7 g/dl for males and females respectively) in their rural subjects despite mean iron intakes of 21 mg per day. These authors considered the possibility that the low haemoglobin levels were due to low intakes of vitamin B6, folate and vitamin C and poor bio-availability of dietary iron. The same possibility exists in the present study, especially among the rural, farm worker and informal settlement strata where vitamin intakes were low.

An outstanding feature of the vitamin intakes obtained in the present study were the low intakes reported by the subjects in farm worker stratum in comparison to those reported by the subjects in the rural, informal settlement, middle class and upper class urban strata. A second notable point is that the large variations in intakes reported for both the present study and other published studies make comparisons difficult. For example, the mean reported intakes of the various subgroups for vitamin A in the present study range from 386 RE in the farm worker stratum to 1739 RE in the upper class urban stratum. The range of intakes reported for urban African subjects is from 373 to 563 RE (Vorster *et al.*, 1997b) while the range for rural subjects is from 946 (Lubbe, 1971) to 1905 RE (Vorster *et al.*, 1997b). From these reports, it appears that vitamin A intakes are higher in rural than in urban areas which is the opposite to the findings of the present study where vitamin A intakes in the urban strata appeared higher. Regarding the B-complex vitamins, mean reported intakes of the rural, informal settlement, middle class and upper class urban strata generally resemble other reported values while those of the farm worker stratum are either on the lower extreme or below reported ranges. The mean intakes of vitamin B12 observed in the present study were higher than the RDA for all strata and in agreement with the range of 3,4 to 10,0 ug reported for urban African populations (Vorster *et al.*, 1997b). The mean intakes of the farm workers were within a similar range to that reported for rural African subjects (2,2 to 3,8 ug) (Vorster *et al.*, 1997b). Mean reported intakes of thiamin, riboflavin, niacin and folic acid are close to or higher than the RDA's for both males and

females for all strata except the farm worker stratum and are also similar to those reported by Vorster *et al.* (1997b). By contrast, vitamin B6 intakes appear lower than the RDA in all strata, in agreement with the values reported by Vorster *et al.* (1997b). Vitamin C intakes were very variable, ranging from extremely low (less than 20 mg in some age groups of the farm stratum) to more than 80 mg per day in the upper class urban stratum. The high variability is confirmed by the large differences which occurred when values were adjusted for constant and proportional bias. Vitamin C intakes reported by other studies have been below the RDA of 60 mg for both urban and rural African populations (Vorster *et al.*, 1997b).

Care must be taken not to draw conclusions about the adequacy of vitamin and mineral intakes based only on mean reported intakes. From Figures 8.13 to 8.18 and Table 8.16, it can be seen that considerable proportions of subjects in the various strata and age groups could be at risk of deficiencies. The most notable are the high percentages of subjects in the farm worker stratum at risk of deficiencies of all reported nutrients except calcium, riboflavin and folic acid. Reported mean intakes of niacin were lower, particularly for the males, in the farm worker stratum than in any of the other strata. This difference is more striking when the percentages of subjects with intakes below 67% RDA are compared (Figures 8.15 and 8.16). For example, in the males younger than 25 years, 75% of those in the farm worker stratum were at risk of a niacin deficiency compared with 22% and 23% in the middle and upper class urban strata respectively. Other studies have reported adequate niacin intakes in the range of 9.4 mg to 25 mg for both urban and rural African populations (Vorster *et al.*, 1997a; 1997b). The differences in niacin intakes among strata may be explained by the source and the amount of maize meal in the diet. In the rural, informal settlement, middle and upper class urban strata, commercial vitamin enriched maize meal was available and used by varying proportions of the samples (Figure 8.20). The farm workers, however, received their maize meal ration directly from the farm cooperative mill, so the maize meal was not enriched. Enriched maize meal contains, on average, 3.4 mg niacin per 100 g dry meal in comparison to approximately 1 mg in unenriched maize meal (Langenhoven *et al.*, 1991a). This difference, together with the limited variety of foods in the farm workers' diets, increases the risk of both subclinical and overt niacin deficiencies among the population of the farm worker stratum.

8.3.4 Food intakes

Considering the diet of the African population of the North West province in terms of foods and food groups shows the differences between strata more obviously than the comparison of nutrients. From Figure 8.19, it can be seen that the variety of foods consumed by the subjects in the farm worker stratum was considerably smaller than in the other strata and possibly explains the lower nutrient intakes seen in this stratum. A limited variety of foods, however, does not necessarily mean that the diet is inadequate (Richardson *et al.*, 1982; Vorster *et al.*, 1994). The diet of rural Venda reported by Vorster *et al.* (1994) comprised only 30 food items, yet the health status of the subjects was good. These authors speculated that maize as the staple food, supplemented with legumes, vegetables and nuts could result in a fairly well balanced diet. Unfortunately this may not apply to the subjects in the farm worker stratum in the present study, as not only were intakes of animal products (except milk) low, but so was the use of legumes and vegetables (Tables 8.16 and 8.17). By contrast, the subjects in the upper class urban stratum consumed a significantly larger variety of foods than any of the other strata, while intakes of the rural, informal settlement and middle class urban strata were very similar.

Tables 8.17 and 8.18 highlight the similarities and differences between strata and genders with regard to the 10 foods consumed in the largest amounts in terms of average daily intakes. The changes in food intakes across strata seem to be more obvious among the females than among the males. For the females, the first four foods (tea, milk, maize meal and sorghum beer) are the same for the rural, farm and informal settlement strata, while in the middle class stratum cold drinks replace sorghum beer, but maize meal remains high on the list. In the upper class urban stratum, maize meal drops to the seventh ranked food. For the males, maize meal is ranked fourth or fifth across all strata.

In comparison to the 'traditional' African diet, changes which become more obvious with the level of urbanisation can be seen. The early surveys of dietary intakes (Quin, 1964; Franz, 1971; Waldman, 1975; Hunter, 1979) described sorghum as the staple food of African populations. Sorghum has obviously been replaced by maize as the staple food throughout the population of the present study and, as can be seen from Tables 8.17 and 8.18, only made a meaningful contribution to the diets of the rural females as porridge. The contribution of sorghum to the diets of the population was mainly as sorghum beer. A similar observation has been reported from a study of rural Xhosas (Rose, 1972). In agreement with other studies of both rural and urban populations (Tables 2.1 and 2.2) maize meal made the largest contribution to the energy intake of the diet in all strata, except the upper class urban stratum (Table 8.19 and 8.20). The trends seen with increasing urbanisation as summarised in Tables

2.1 and 2.2 are also seen in the present study by the increased use of meat, fruit and vegetables. The food consumption pattern of the upper class urban subjects is different to those reported by other urban studies where maize meal has remained a staple food (Crous & Borchardt, 1982; 1984; Bourne *et al.*, 1994; van Eeden & Gericke, 1996). The food consumption pattern, however, is similar to that found for African medical students (MacIntyre *et al.*, 1998) and approaches that of white populations (Wolmarans *et al.*, 1989; Vorster *et al.*, 1995).

Not only were there differences in the maize meal consumption patterns, but also in the consumption of other cereals. Bread made the smallest contribution to the diet of the farm workers (providing 5,4 and 5,6 of the total energy intake for women and men respectively), while its consumption was fairly similar for the other strata (providing between 8% and 12% of the total energy intake). In a survey of national trends in bread consumption (Jooste *et al.*, 1994), increasing socioeconomic levels were associated with higher consumption of white bread. The association of type of bread and stratum of urbanisation is not very clear in the present study. In the farm worker and informal settlement strata, the proportion of white bread was higher than brown bread, while in the middle and upper class urban strata the proportions of white and brown bread consumed were similar. A greater percentage of subjects in the rural stratum used brown bread than white bread. Possible reasons for these differences have been suggested in the Results section (8.2.8.2).

As pointed out in the discussion on nutrient intakes, the consumption of milk and milk products in all strata except that of the farm workers was low. This finding is an agreement with milk intake patterns of both rural (Bursztyn, 1985; O'Keefe *et al.*, 1985; Huss-Ashmore & Curry, 1991; Ladzani *et al.*, 1992; Vorster *et al.*, 1994) and urban African populations (Crous & Borchardt, 1984; Bourne *et al.*, 1994; MacIntyre *et al.*, 1998). Contradictory to other studies (Ladzani *et al.*, 1994) non-dairy milk substitutes were rarely used.

Meat and meat substitutes made the highest contribution to the energy intake in the upper class urban stratum and the lowest contribution in the farm worker stratum. Meat consumption patterns of the rural, informal settlement and middle class urban strata were similar, providing approximately 20% of the total energy intake. The most outstanding difference is in red meat consumption in the upper class urban stratum where the percentage energy derived from red meat was double that of the rural stratum and triple that of the farm worker stratum. Interestingly, the consumption of chicken, fish

and legumes was very similar across all strata. Possibly, an explanation for the similar chicken consumption is that chicken is typically eaten on Sundays, irrespective of other meat eaten during the week. Thus, while, in the poorer strata, chicken eaten on Sundays may be the only meat consumed during the week, in the better off strata, chicken is consumed on Sundays in addition to other types of meat during the week.

In agreement with other studies of African food intakes (Lubbe, 1971; Manning, 1974; Ladzani *et al.*, 1992; Bourne *et al.*, 1994; van Eeden & Gericke, 1996), fruit and vegetable consumption was low, only showing an increase in the upper class urban stratum. This trend is in contrast to the 'traditional' African diet in which a variety of wild and cultivated vegetables made a substantial contribution to the diet (Quin, 1964; Franz, 1971; Lubbe, 1971; 1971b; Grivetti, 1976; Hunter, 1979). The reasons for the low consumption of vegetables and fruit can be speculated. In the rural areas, because of the harsh climate, poor soil, lack of water and loss of land, cultivation is difficult and wild fruits and vegetables do not grow readily. Also, as discussed in Chapter 2, migration mainly of men out of the rural areas, increased the work load of the women who found it difficult to cultivate vegetable crops under the adverse conditions. In urban areas, fresh vegetables and fruit are relatively expensive and in the informal settlement areas space for cultivation is limited. The three most common reasons given by subjects in a semi-rural area for not cultivating vegetable gardens were lack of water, time and space (Ladzani *et al.*, 1992).

The use of fat in cooking and as an addition to other foods was lowest in the farm worker stratum but was very similar in the other four strata. As already pointed out under Results, the proportions of fat reflected in Tables 8.19 and 8.20 reflect only fat added to foods. The most popular form of fat used for food preparation in all strata was sunflower oil, which was the main source of polyunsaturated fats. Since the use of added fat was fairly similar for the rural, informal settlement, middle class urban and upper class urban strata, the differences seen in total fat intake are probably due to the high red meat consumption in the upper class urban stratum. The percentage of energy provided by added fat is lower for all strata than that reported for Africans in the Western Cape (7,3% and 8,4% for males and females respectively) (Bourne *et al.*, 1994).

Regarding sugar intakes, again the most noticeable differences occurred between the farm worker and the upper class urban strata. Although the differences between the first four strata were not

significant, the percentage of the total dietary energy provided by sugar (8%) was highest in the farm worker stratum. By contrast, the use of sweets, cakes and cold drinks was lowest in the farm worker stratum. These differences reflect the availability and affordability of these products in the different areas. The subjects in the farm worker stratum do not have regular access to shops and with limited incomes cannot afford 'luxuries'. In the rural, informal settlement and middle class urban areas, sweets and cold drinks are sold at 'tuck' shops or 'Spazas' (see Chapter 3). The prices, however, are usually somewhat higher than in the towns. For the subjects in the upper class urban stratum, these 'luxuries' are both very easily available and affordable.

Alcohol intakes, as seen by both alcohol expressed as a nutrient (Tables 8.9 and 8.10) and as the energy provided by alcoholic beverages (Tables 8.19 and 8.20) were very variable as seen by the high standard deviations and poor agreement in the relative validation study. Alcohol intakes for the women in all strata were low. Among the males, however, alcohol contributed between four and 11% of the total dietary energy. Commercial beer, sorghum beer and home brew were the most popular beverages, a finding which is in agreement with Ramphele & Heap (1991). Alcohol intake was highest in the informal settlement and upper class urban strata. Bursztyn (1985) reported an average of 29% of total energy intake provided by alcohol among rural middle class males in Zimbabwe.

8.3.5 Comparison to food group recommendations

The comparison of the food group intakes of the subjects in the present study with the recommendations of the Department of Health and Welfare (1992) summarises the short comings of the diets of the various strata of urbanisation and highlights the differences among strata. Only the milk intake of the subjects in the farm worker stratum met the recommended 400 ml per day, and this was only because the farm workers received a milk ration. In all the other strata, milk intakes were barely half the recommendation and were reflected in low calcium intakes throughout the study population. Intakes of the meat group met the recommendations for all strata except the farm worker stratum. Regarding fruit and vegetable intakes, only the upper class urban stratum achieved the recommended intake. On the other hand, cereal intakes exceeded the recommendations. Fat intakes were below recommendations. However, as already explained these include only added fat while the recommendations include both visible and invisible fats. A similar picture of food group consumption, that is, low milk intake, adequate meat intake, low fruit and vegetable intake and high cereal intake

was reported from the Western Cape (Bourne *et al.*, 1994).

8.3.6 The nutrition transition in the North West province

From the discussion of the results of the dietary intake study of the African population of the North West province, it is clear that the diet is in a state of transition. It is also evident that the changes occurring in the diet are typical of those reported from other countries undergoing the nutrition transition, that is, there is a shift away from a predominantly cereal based, low fat diet to a diet in which the use of traditional cereals decreases while the intake of fat and refined foods increase (Popkin *et al.*, 1992; Monteiro *et al.*, 1995; Cannan & Walker, 1996a; 1996b; Drewnowski & Popkin, 1997) (see Chapter 2: 2.3).

The pattern of transition in the present study might have been expected to follow a fairly even progression from the rural diet which would resemble the 'traditional' diet most closely, gradually changing through each level of urbanisation until becoming a typical 'western' diet in the upper class urban stratum. This, however, was not the case. There were very few significant differences between the diets of the subjects in the rural, informal settlement and middle class urban strata, nor were there any notable differences in nutritional status as assessed by body mass index. Thus, it appears that these three strata may represent a single level of urbanisation. Reasons for this similarity may be that there was considerable contact and movement between the strata and as pointed out in Section 8.3.1 boundaries between strata are fairly blurred. Also, with regard to the discussion of the process of urbanisation in Chapter 2 (2.2.2), the distinction between the 'rural' and 'urban' areas in the present study in terms of level of urbanisation was not clear. The rural areas visited met the criteria by falling under a tribal authority, however, according to the classification of Gelderblom and Kok (1994) (Chapter 2: 2.2.2.1) could be classified as closer settlements or homeland fringe settlements. Thus, there was not a strong agricultural base, many of the inhabitants were migrant workers and most of the inhabitants depended on income from the urban areas. Migration also may have contributed to the similarities between these strata. Also, the majority of subjects in the informal settlement stratum were fairly recent arrivals from rural areas. Thus, the rural influences on lifestyle might still have been present. Continual movement of members of the population between rural and urban areas as in circular migration and contact of permanent migrants with their areas of origin (see Section 2.2.2.1.2) may result in urban lifestyles influencing rural and vice versa.

Compared to the rural, informal settlement and middle class urban strata, the farm worker stratum formed a very distinct group. As was evident from the results of the questions on urbanisation, there was very little movement of subjects into or out of the stratum. The farm workers lived on the employers' farms and were largely dependent on their employers for both their livelihoods and their food supplies. Although the macronutrient composition of the diet resembled that of the high carbohydrate, low fat 'traditional' diet most closely, the nutritional adequacy was clearly questionable in terms of energy, protein quality and micronutrient intakes.

On the opposite extreme of urbanisation, the upper class urban stratum, also seemed to form a fairly distinct category. The composition of the diets of the subjects resembled that of 'western' populations most closely. The differences between this and the other strata were most apparent in the lower consumption of maize as a staple food, the high red meat intakes and higher consumption of fruit and vegetables. From the point of view of nutritional adequacy, the diet of the upper class urban strata came closest to the recommendations of the Department of Health.

8.4 RECOMMENDATIONS REGARDING THE QFFQ

One of the difficulties experienced with QFFQ was the length of time the interviews took. The following recommendations are made to cut down the repetition and hence the time needed for completion.

- (a) The questions concerning usual meal patterns were too repetitive and confusing. This section should be shortened and asked in the form of a 24-hour recall.
- (b) The questions regarding the use and type of milk and sugar with porridge or breakfast cereals should only be asked once, after the section including porridges, rather than after each type of porridge or breakfast cereal.
- (c) Beef, mutton, pork and canned meat should be combined in one section of 'red meat'. Beef offal, bacon, sausages and cold meats, however, should be kept separate.
- (d) The questions on polony should be removed from the section of bread and bread spreads.

- (e) The question on the use of custard and canned fruit should be asked only once, under puddings.

8.5 SUMMARY AND CONCLUSIONS

In the discussion of the nutrition and health transition in the Literature Review (2.3), the point was made that changes due to urbanisation frequently result in the coexistence of dietary intakes which are conducive to undernutrition and intakes which could predispose to the development of NCDs within the same population. This situation seems to be true for the population of the North West province. Although there was no evidence of the 'traditional' hunter-gather food pattern which resulted in intakes high in carbohydrate and fibre and low in fat in the present population, the diets of the majority of the population maintained a high staple cereal content. However, with changes to the staple cereal and increased processing, much of the high fibre content has been lost. In terms of the transition model proposed by Popkin (1993), the 'collecting food' pattern may be accompanied by a 'famine' dietary pattern characterised by periods of food shortages. This is followed by the 'receding famine' pattern in which consumption of animal protein, fruit and vegetables increases and the staple cereal intake declines. In the present study, there was evidence of the 'famine' stage in the farm worker stratum, as well as among subjects in the rural and informal settlement strata according to the percentages with micronutrient intakes at risk of deficiencies. It seems, however, that the majority of the population were in a similar phase of transition to that of the 'receding' famine, that is, cereal intake was still high but was being replaced to some extent by animal protein and fat. Unfortunately, the increased intakes of fruit and vegetables appeared to be taking place to a lesser extent and primarily in the higher strata of urbanisation. The dietary intakes of the subjects in the upper class urban stratum displayed evidence of the beginnings of the 'degenerative stage' characterised by high fat and refined carbohydrate intakes and low fibre intakes.

The results obtained from the dietary intake study have met the overall aim of the THUSA project, that is, to provide information for the development of appropriate strategies which will provide adequate diets to the population while limiting changes in the direction of the degenerative pattern. The results have been used to design an intervention and education programme known as the 'The Great Eight Nutrition Programme' which is currently being implemented in the North West province.

Since urbanisation is a rapid and ongoing process, it will be necessary to repeat the dietary intake study (together with the other components of the THUSA project) at regular five to 10 year intervals to monitor changes in the dietary intakes and health status of the population of the North West province.

CHAPTER 9

SYNOPSIS, RECOMMENDATIONS AND CONCLUSIONS

9.1 SYNOPSIS

The overall objective of the present study was to develop a culture sensitive, reproducible and relatively valid quantitative food frequency questionnaire (QFFQ) and food portion photograph book (FPPB) for the collection of dietary intake data of the African population of the North West province as part of the THUSA study. Since the purpose of the THUSA study was to compare risk factors for NCD's among strata of urbanisation of the population of the North West province, it was important that the instrument developed would not only be sensitive to the culture of the study population but would also be able to identify differences between dietary intakes of the levels of urbanisation. It was therefore necessary that the QFFQ and FPPB be developed within the context of the historical and cultural background of the study population as well as the process of urbanisation. The Literature Review (Chapter 2) attempted to bring together the theory of urbanisation and the importance of the use of appropriate dietary assessment methods.

In order to achieve the main objective a series of interlinked studies, each aimed at a component of the main objective, was carried out. This chapter will summarise each of these studies and examine how closely they came to meeting the objectives.

9.1.1 Culture-sensitive quantitative food frequency questionnaire

In order to develop a QFFQ and FPPB appropriate for use among the African population of the North West province, an understanding of the culture related to food behaviours was needed. The starting point in this process was a preliminary study which made use of both qualitative and quantitative research methods to describe the food intake patterns, food preparation methods and common portion sizes used by the population of the North West province (Chapter 3). The information obtained during the preliminary study was used to identify the most commonly consumed foods, methods of preparing these foods and the serving sizes and methods. These foods were then prepared and photographed in three or four portion sizes. The colour

photographs were enlarged and put together into A3-sized, laminated books. To ensure that the food photographs could be interpreted by the study population, the FPPB was tested in a sample of 169 volunteers from the Ga-Rankuwa region of the North West province (Chapter 4).

Teufel (1997) has advocated the use of the term 'culturally competent' to describe a food frequency questionnaire which not only recognises the unique behaviours of a culture (cultural awareness), accommodates these behaviours (culturally sensitive) in an inoffensive and useful way (culturally appropriate), but also uses this cultural knowledge and perspective to work within the context of the study population. The QFFQ developed in the present study will be compared to the steps proposed by Teufel (1997) for the development of culturally competent food frequency questionnaires to see how close it came to meeting these criteria.

9.1.1.1 Development of culturally specific food lists and food groups

Information on culturally specific foods and preparation methods was obtained using unstructured interviews in the first phase of the preliminary study. Since the researcher might have interpreted the information from her own cultural perspective rather than from that of the participants, focus groups were used to confirm and correct the food information and food preparation methods. The grouping of food on the QFFQ was done based on the most frequently eaten foods and foods commonly eaten together. Possibly, more appropriate groupings could have been achieved by asking focus group participants to group foods from their own perspective (Teufel, 1997).

9.1.1.2 Creation of a culture specific database

Development of a culture specific database requires the information on food preparation methods and recipes. This was achieved from descriptions of food preparation methods by the participants, the focus group discussions and the actual preparation of recipes. This information was added to the food database as recipes and used for dietary analysis. Had time and facilities allowed, 'cooking sessions' at which women of the community prepare dishes and ingredients are measured might have produced more accurate data. Nevertheless, it was believed that the methods used in the present study were sufficient to provide useful information. A concern at the start of the study was that the Food Composition Tables (Langenhoven *et al.*, 1991a) might not have

contained nutrient values of wild foods. However, little use was made of these foods by the study population.

9.1.1.3 Definition of culturally appropriate serving sizes

Appropriate serving sizes were determined from both the qualitative interviews and from the consensus reached at the focus group discussions. In addition, the testing of the FPPB (Chapter 4) ensured that the portion size photographs could be interpreted by members of the study population. Further, the use of common dishes and serving utensils during the interviews, helped to identify serving sizes.

9.1.1.4 Comprehensive assessment of the QFFQ

Participants in the pilot study were asked to comment on the food list, food descriptions and question style of the QFFQ. In addition, during the training sessions, field workers made suggestions for the improvement of the wording and descriptions particularly with regard to appropriate translations into Tswana. A more formal evaluation, as suggested by Teufel (1997) could have identified further points that needed clarification or modification.

The process of the development of a QFFQ is a continual one. In fact, it is unlikely that the 'perfect' QFFQ could ever be achieved. During the data collection phase, problems and deficiencies of the QFFQ and FPPB which were not seen in the initial development phases became apparent. Among these was the time that the interview took to complete resulted in some subjects becoming bored and in some cases, field workers might have skipped questions. The measures built in as cross-checks (for example asking twice about polony and atchar) increased the length of the QFFQ and confused some subjects. Many subjects did not distinguish between types of red meat, so the divisions into beef, mutton and pork seemed repetitive and could have resulted in some overestimation of meat intakes (although this was not apparent from the relative validation study). Subjects had difficulty in expressing frequencies, especially of infrequently used foods and additional food portion photographs were needed. Nevertheless, although the term 'culture sensitive' has been used throughout this thesis, from comparison with the guidelines proposed by Teufel (1997), the QFFQ developed in the present study seems to go

beyond being culturally sensitive to approaching the standards required for cultural competency. Further work on the QFFQ, FPPB and food database as well as on the validity and reproducibility is needed, however, before the QFFQ can be accepted as culturally competent.

9.1.2 Reproducible and relatively valid

Concurrent to the development of the FPPB was the design and pilot testing of the interview schedule which included questions on level of urbanisation and meal patterns as well as the QFFQ. This stage included the recruitment and training of the field workers and integration into the planning of the THUSA study (Chapter 5).

The reproducibility and relative validity were tested concurrently to the main THUSA study, using sub samples of volunteers. Reproducibility (Chapter 6) was tested by a second administration of the QFFQ three to 12 weeks after the initial interview on a sample of 144 volunteers. Although correlation coefficients between nutrient and food intakes derived from the first and second administrations were low, comparison of mean intakes using the paired t-test, and agreement based on Bland-Altman plots and quintile distributions were satisfactory, especially for energy and carbohydrate. Also, it was clear that the reproducibility was not significantly affected by gender, age, body mass index or stratum of urbanisation.

The determination of the relative validity of the QFFQ was the most difficult and complex phase of the development process (Chapter 7). The relative validation study comprised three components. First, the results of the QFFQ were compared to nutrient intakes derived from seven-day weighed food records kept by a sub sample of 74 volunteers. Second, the protein intakes were compared to excretion calculated from the nitrogen content of 24-hour urine collections obtained from 88 subjects. Third, the percentage of subjects who were possible underreporters was determined using the ratio of energy intake to basal metabolic rate for both the sub sample (N=74) and the entire dietary intake sample (N=890). The data was analysed using the Spearman rank correlation coefficient, paired t-tests, quintile distribution and Bland-Altman plots. In addition, structural equation modelling (SEM) was applied to determine the degree of constant and proportional bias and the correlation of the QFFQ with the true intake. Comparison of the results of the QFFQ with the seven-day weighed record showed that there was

a tendency to underreport on the QFFQ. More detailed analysis using the SEM, however, showed that underreporting was not consistent throughout the sample, but varied depending on the nutrient and the level of intake. Comparison with the 24-hour urinary nitrogen excretion failed to produce meaningful results. The possible reasons for this were explored in Chapter 7, but the most likely one is that most collections were incomplete. Use of the basal metabolic rate as an indicator of underreporting showed that approximately 40% of the sample was possibly underreporting their energy intakes. Since the proportion of underreporters was not affected by gender, age group, body mass index or stratum of urbanisation, underreporting should not interfere with comparisons between subgroups. When all the results of the relative validation study were taken together, the QFFQ appeared to give relatively valid results for energy, the macronutrients, calcium, vitamin A and vitamin C. Results obtained for iron and fibre for the main dietary intake study, however, need to be interpreted with caution.

9.1.3 Able to assess the dietary intakes of the African population of North West province

The ultimate test of the usefulness of the QFFQ and FPPB was the application of these instruments to the assessment of the dietary intakes of the THUSA sample (Chapter 8). The QFFQ and FPPB were therefore used to assess the dietary intakes of 890 subjects from five strata of urbanisation. As this step was the final phase of the development of the QFFQ, the results were compared within age groups between strata. Detailed statistical analyses to identify associations between strata, genders and age groups or associations between dietary intakes and other parameters measured by the THUSA study were not performed. An attempt was made to interpret the findings in the light of the results of the relative validation study. The results indicated two extremes of intakes that clearly differed from the other strata. On the one hand, the dietary intakes of subjects in the farm worker stratum were lower in energy, animal protein, fat and micronutrients and higher in carbohydrate than the rural, informal settlement, middle class urban and upper class urban strata. On the other hand, the dietary intakes of the subjects in the upper class urban stratum were higher in fat, lower in carbohydrate and more adequate in micronutrients. Few differences were apparent between intakes of the subjects of the rural, informal settlement and middle class strata. It is not clear whether few differences were found because of true similarities between these strata (as discussed in 8.6) or whether the QFFQ was

not sensitive enough to pick up smaller differences among strata. In summary the dietary intakes of the rural, farm, informal settlement and middle class urban strata met the prudent diet guidelines for carbohydrate, protein and fat, but were low in micronutrients. The diet of the upper class urban stratum tended towards the western type diet associated with chronic diseases of lifestyle, that is, the carbohydrate content showed a decreasing trend while fat intakes were increasing. Micronutrient intakes, however, were higher. In terms of food groups, the first four strata consumed a diet in which maize meal was the dominant food, but where meat and fat consumption increased with availability. Fruit, vegetable and milk intakes were generally low. In contrast, no single food was dominant in the diets of the upper class urban strata, meat and meat products were consumed in larger amounts, a wider variety of cereals were used and fruit and vegetable intakes were slightly higher. Milk intakes were similar to that of the other strata.

9.2 RECOMMENDATIONS

9.2.1 Improvements to the interview schedule and food portion photograph book

9.2.1.1 Quantitative food frequency questionnaire

Following the suggestion of Teufel (1997) that the grouping of foods on the questionnaire be based on the way in which the respondents think about food in their own culture, a study needs to be conducted, possibly using focus groups, to determine the best way in which to group foods on the QFFQ. This could clarify, for example, whether canned fruit should be listed under 'fruit' or 'puddings'. Such a process could show that the groupings need to be completely reorganised.

Particular difficulties were experienced in obtaining information on the amounts and frequencies of fat used in cooking and on the use of alcoholic drinks. The section on fats (Appendix F, page 522) did not yield useful information. The whole question of assessing fat intake needs to be looked into and alternate ways of obtaining information on fat intakes examined. Quantification of alcohol intake was straight forward for occasional drinkers as most could be specific about how often and how much alcohol they drank. Regular drinkers, however, were far more difficult to assess. It is common practice for a group of friends to share cases of beer over a few hours and so not keep track of the number of cans or bottles they consume. Quantifying the intake of

home brewed beer was also difficult. Again, ways of quantifying alcohol intakes more accurately need to be investigated.

The reproducibility and relative validation studies identified difficulties in assessing intakes of particularly fibre, iron and vitamin A. Revision of the QFFQ could help to rectify these problems. In addition, specific strategies for improving the assessment of these nutrients need to be explored. For example, Kemppainen and co-workers (1993) have developed a qualitative fat index for the assessment of fat intake while questionnaires designed specifically to assess vitamin A intakes have been used in several developing countries (Baker *et al.*, 1997; de Pee *et al.*, 1997; Nnanyelugo & Onofiok, 1997).

Further study is needed in conjunction with cognitive psychologists into the cognitive processes involved in the recall and reporting of dietary data. Such information could lead to different and possibly more effective approaches to the collection of dietary information.

9.2.1.2 Food portion photograph book

The recommendations concerning the FPPB were discussed in detail in Chapter 4. Use of the FPPB in the main dietary intake study showed that the book did depict the most frequently consumed foods. Possible additions could be photographs of seasonal fruit such as mangoes and peaches, vegetables such as carrots, mashed potatoes, green beans and sweet potatoes, different consistencies of porridge in addition to stiff and soft (this might be difficult to achieve in practice), thicker slices of bread and larger fat cake sizes.

9.2.2 Reproducibility study

In comparison to other published studies, in terms of reproducibility, the QFFQ did not perform well. The reproducibility of the staple food, maize meal, however, was satisfactory.

- (a) A more random, representative sample, rather than only volunteers, should be selected to ensure that the results of the reproducibility study can be applied to the total sample.

- (b) The interval between administrations should be consistent.
- (c) Weights of subjects should be measured at each administration to check for changes in weight status.
- (d) Ways of differentiating between actual changes to dietary intakes and effects of the QFFQ need to be explored. One possibility is the use of a 'store turnover' inventory as used by Lee and co-workers (1995) to assess dietary intakes of Australian aboriginal communities could be considered to monitor changes in food patterns at a community level.

9.2.3 Relative validation study

Detailed recommendations were given regarding the relative validation study in Chapter 7. The following summarise the recommendations made previously:

- (a) Methods of determining relative validity in populations with low literacy levels require further investigation. Such methods would mean that more representative samples could be selected.
- (b) Methods of collection and validation of 24-hour urine samples need to be improved before this method can be applied in other studies.
- (c) Alternative reference methods and biomarkers which place lighter burdens on the respondents need to be explored
- (d) Accurate information on energy expenditure and requirements in African populations is needed to ensure that comparative ratios based on energy intakes and expenditures are realistic.
- (e) There is a great need for both national and international standards regarding methods, statistical techniques and acceptable limits of validity to be established.

All of the above recommendations are complex and most would require more expertise and resources than are available to a single researcher or institution. It is therefore recommended that the development of procedures to test the validity of dietary intakes assessment instruments be approached by collaboration between research centres involved in dietary assessment, both within South Africa and internationally.

9.2.4 Dietary intake study

Application of the above recommendations to the QFFQ, FPPB and reproducibility and relative validation studies should result in an improved assessment instrument which would reflect the dietary intakes of the population more accurately and possibly be more sensitive to differences between sub groups of the population. Regarding the overall study design, the following recommendations can be made:

- (a) Some bias might have been introduced into the sample by the localities of the research centres. In the rural, informal settlement and middle class urban strata, research centres were at clinics or community halls. Thus, subjects who were recruited were mostly those who were at home during the day (house wives or unemployed), lived in the vicinity of the research centre or who were attending or accompanying somebody attending the clinic. In the upper class urban strata, the research centre was located at schools and places of employment such as the Department of Health and the University of North West. Hence, the majority of these subjects were employed, scholars or students. The farm worker stratum comprised farm workers and their wives from four farms. This resulted in a smaller sample size and a non random sample which could account in part for the differences observed between the farm worker and the other strata. Given the circumstances in which the study was conducted, the design was the most practical and cost efficient. Nevertheless, methods to select more random samples need to be considered, for example, house to house visits and the use of aerial photographs to select homes.
- (b) More detailed information than only place of residence is needed to classify subjects according to levels of urbanisation and acculturation. Such information could include

more precise details on the time lived in a specific area, cultural practices and social interactions. To achieve this, a multi-disciplinary team of researchers including sociologists and social anthropologists would be necessary.

- (c) As pointed out in Chapter 8 the dietary intake study formed part of the development process of the QFFQ and the FPPB. Hence the dietary data was not analysed in great detail. In line with the objective of the THUSA study, associations between dietary intakes, health parameters and other risk factors for NCD's and differences among strata of urbanisation need to be analysed and reported on. Care must be taken, however, to include the limitations identified by the relative validation study in the interpretation of these findings.

9.3 CONCLUSIONS

9.3.1 **The development of a culture-sensitive quantitative food frequency questionnaire and food portion photograph book**

It was possible to develop a QFFQ and FPPB sensitive to the culture of the African population of the North West province by using a combination of qualitative and quantitative research methods and by testing the instruments in the target population. Further improvements, however, especially regarding cognitive and cultural processes could enhance the usefulness of the instrument.

9.3.2 **The reproducibility of the quantitative food frequency questionnaire**

In comparison to other studies, the QFFQ did not appear to perform well regarding reproducibility. Nevertheless, reproducibility was satisfactory for energy, the macronutrients and the staple food intakes of the population of the North West province. Furthermore, there did not appear to be differences in reproducibility among sub groups of the population.

9.3.3 The relative validity of the quantitative food frequency questionnaire

Relative validation against a seven-day weighed record as the reference method gave satisfactory results for energy, the macronutrients, calcium, vitamin A and vitamin C. Basal metabolic rate appeared to be a more practical biomarker than urinary nitrogen in the study population. The application of the Bland-Altman technique, SEM and the estimation of variance components to the data provided additional information regarding the presence of bias and the relationship of the dietary information obtained from the QFFQ to the true intake of the population. A combination of methods and statistical techniques were necessary to test the relative validity of the QFFQ. When all the results were taken together, the QFFQ could be accepted as a relatively valid assessment instrument of the dietary intakes of the population of the North West province.

9.3.4 The usefulness of the quantitative food frequency questionnaire and food portion photograph book

The QFFQ and FPPB were successfully used for the collection of the dietary intake data of the African population of the North West province. The QFFQ was able to identify differences in intakes among the strata of urbanisation and to produce results comparable to those of other studies of African populations.

The primary purpose of this study has therefore been achieved, that is, a reproducible, relatively valid culture-sensitive QFFQ and FPPB for the collection of dietary information of the African population of the North West province of South Africa were successfully developed and implemented.

CONGRESS PRESENTATIONS

The following papers and posters, based on this thesis, have been presented:

MacIntyre UE, Venter CS & Vorster, HH. Nutrition transition in North West Province, South Africa (Poster). 16 th International Congress of Nutrition, Montreal, Canada: 27 July - 1 August 1997.

MacIntyre UE, Venter, CS, Steyn, HS. The relative validation of a quantitative food frequency questionnaire using seven-day weighed records and biomarkers. Fifth biennial congress of the Association for Dietetics in South Africa and 17th biennial congress of the Nutrition Society of Southern Africa. Sun City. 25-29 May, 1998.

MacIntyre UE, Venter, CS. The development and testing of a food portion photograph book for use with a quantitative food frequency questionnaire. Fifth biennial congress of the Association for Dietetics in South Africa and 17th biennial congress of the Nutrition Society of Southern Africa. Sun City. 25-29 May, 1998.

Steyn, HS, MacIntyre UE, Venter, CS. Geldigheidsbepaling van 'n dieetvraelys deur van strukturele vergelykingsmodelle gebruik te maak (Determination of the validity of a dietary questionnaire using structural equation models). 1997 South African Statistical Association Congress. Dikhololo. 5 - 7 November, 1997.

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APPENDIX A
PRELIMINARY STUDY INTERVIEW SCHEDULE

INTRODUCTION

Good day! How are you?

My name is Una MacIntyre and this is Cecilia Tau.

Thank you for being willing to speak to us.

We want to find out about what the people who live here eat and drink. Can we please ask you some questions about where you get your food from, how you cook it and how, when and where you eat it? We really want to know how you eat from day to day, not how you eat on special occasions. We would also like to see and measure the utensils you use for measuring and serving food.

Please ask questions if you do not understand anything. What you tell us is confidential. We will not talk about it to anybody else. We are using a tape recorder so that we can be sure that we have all the information you give us accurately.

We first want to ask some questions about you and your family.

SECTION A: DEMOGRAPHIC DATA

Subject Number _____ Area _____

Date _____ Observer _____

Name _____

Address _____

Date of Birth (dd/mm/yy) _____

Age _____

Number of people in household

	MALES	FEMALES
Adults (older than 20 years)		
Teenagers (13 - 19 years)		
Children (6 - 12 years)		
Children (1 - 5 years)		
Infants (younger than 1 year)		

Home Language _____

Home Language of father _____

Home language of mother _____

How long have you lived in this village / town ?

Since birth	
Came as a child	
More than 10 years	
Between 6 - 10 years	
Between 1 - 5 years	
less than a year	

If you have not lived in this village/town since birth or since you were a child, where did you live immediately before you came here ?

Ask subjects living in urban areas :

	YES	NO	DON'T KNOW
Do you have family living in rural areas ?			
If Yes , Do you visit them ?			
When did you last visit them ?			
How often do you visit them in a year (from Christmas to Christmas)			

SECTION B: ENVIRONMENT

(tick applicaple options)

1. Type of house

Mud hut	
Shanty - corrugated iron & wood	
Wood	
Brick	
Other	

2. Water supply

Inside taps	
Outside tap	
Communal tap	
Communal pump	
River	
Other	

3. Heat source

Electricity	
Gas	
Wood	
Coal	
Paraffin	
Cattle dung	
Other	

4. Food preparation and cooking area (where cooking is usually done):

Description :

Separate kitchen, inside house		
Inside house, but not a separate area		
Closed in area, separate from house		
Outside, private area		
Outside, communal area		
Other		

5. Cooking apparatus :
(mark as many as appropriate)

Stove	
Oven	
Hot plate	
Open fire	
Bola	
Griller	
Electric frying pan	
Microwave oven	
Other - describe	

6. Food storage
(mark as many as necessary)

Refrigerator	
Freezer	
Refrigerator/freezer combination	
Closed cupboards	
Open shelving	
Other - Describe	

7. Food sources :
(mark as many as appropriate)

Description : *
Frequency of
purchase/acquisition:

Own vegetable garden			
Own fruit trees			
Own cattle			
Communal vegetable gardens			
Communal fruit trees			
Communal cattle			
Gathering from veld			
Local stores			
Town/city stores			
From employer			
From family			
From friends			
Other - describe			

- * 1 - Daily
3 - 2-3 times per week
5 - 2-3 times per month
7 - less than once per month (specify)
- 2 - 4 - 6 times per week
4 - once a week
6 - once per month

SECTION C : FOOD INTAKE RECORD

SUBJECT NO

DATE _____

DAY

[illegible]

3 : CAPACITY OF HOUSEHOLD UTENSILS

SUBJECT NUMBER

DATE : _____

We need to know about the utensils and dishes you use to prepare and serve food. Would you show them to us ? Can we measure them ?

[illegible]

APPENDIX B**PREPARED FOODS TAKEN TO FOCUS GROUPS: 13-17 NOVEMBER 1995****Group 1: Moshawane**

Stiff porridge
Samp and beans
Samp and peanuts
Rice
Vetkoek
Dumpling
Chicken stew
Pilchards with onion
Cabbage with potato and onion
Curried cabbage with potato and onion
Mashed pumpkin
Tomato and onion gravy
Beetroot
Canned peach slices
Custard
Sweets and chocolates

Group 2: Barberspan Farms

Stiff porridge
Samp and beans
Rice
Vetkoek
Dumpling
Chicken stew
Pilchards with onion
Cabbage with potato and onion
Curried cabbage with potato and onion
Spinach with potato and onion
Tomato and onion gravy
Beetroot
Canned peach slices
Custard
Sweets and chocolates

Group 3: Ikageng

Stiff porridge
Samp and beans
Rice
Vetkoek
Brown bread
Meat stew
Cabbage with potato and onion
Curried cabbage with potato and onion
Carrots and potato
Spinach with potato and onion
Tomato and onion gravy

Beetroot
 Canned peach halves
 Custard
 Atchaar
 Polony
 Apricot jam
 Peanut butter
 Sweets and chocolates

Group 4: Top City

Stiff porridge
 Samp and beans
 Rice
 Vetkoek
 Brown bread
 Chicken bone stew
 Chicken feet stew
 Cabbage with potato and onion
 Curried cabbage with potato and onion
 Pumpkin
 Spinach with potato and onion
 Tomato and onion gravy
 Beetroot
 Atchaar
 Polony
 Canned peach slices
 Custard
 Apricot jam
 Peanut butter
 Sweets and chocolates

Group 5: Fochville Farm

Stiff porridge
 Samp and beans
 Rice
 Vetkoek
 Brown bread
 Meat stew
 Pilchards and onion
 Cabbage with potato and onion
 Curried cabbage with potato and onion
 Carrots and potato
 Spinach with potato and onion
 Tomato and onion gravy
 Beetroot
 Canned peach slices
 Custard
 Apricot jam
 Peanut butter
 Sweets and chocolates

APPENDIX C

FOCUS GROUP : DISCUSSION GUIDE

Introduction:

Thank you all for giving up your time to come to meet us today. We appreciate it very much. We learnt a lot from the last time we visited you. Now we would like to check with you that we understood what you told us and to ask you a few more questions.

1. Food preparation

First I am going to ask you to taste a little of each of the foods we have brought. When you have tasted it, we will ask some questions about it.

1.1 Porridge

When you make stiff porridge, how much mealie meal and how much water do you use?

When you make soft porridge, how much mealie meal and how much water do you use?

Do you add salt to the porridge?

If yes, how much salt do you add?

If you make mabella porridge, which type do you use ?

The fine one or the course one?

1,2 Vegetables

Please taste the cabbage.

Does it look and taste like the cabbage you cook?

If not, what should be done?

How do you cook cabbage?

Please taste the tomato and onion gravy.

Does it look and taste like your tomato and onion gravy?

If not, what needs to be done?

How do you cook tomato and onion gravy?

Please taste the carrots.

Does it look and taste like the one you cook?

If not, what needs to be done?

How do you cook carrots?

Do you mash it or leave it in blocks?

1.3 Samp and Beans

Please look at the samp and beans. Are the amounts of samp and beans right?

Do you mash the beans?

When you cook samp and beans, how many cups of raw samp and how many cups of beans do you use?

Do you add salt?

If yes, how much?

1.4 Meat stew/chicken stew/ chicken bone stew

Please taste the stew.

Does it look and taste like the stew you cook?

If not, what should be done?

What vegetables do you put in a stew?

1.5 Vetkoek and dumpling e vetkoek and the dumpling.

What size is the vetkoek you make?

Do these vetkoek taste like the ones you make?

If not, what is different?

Do you make vetkoek with yeast or baking powder?

Do you eat your vetkoek hot or cold?

Do you eat it like this every time?

What is your recipe for vetkoek?

What size is the dumpling you make?

Does this dumpling taste like the one you make?

If not, what is different?

What is your recipe for dumpling?

Do you eat the dumpling hot or cold?

2. **I am now going to ask some questions about how you serve food.**

2.1 Do you keep food from meal to meal?

If yes, what food do you keep?

How do you store it?

Do you reheat it again before eating?

2.2 Food serving

How do you serve the family food? (Do you dish up for each one, does husband dish up, does each serve himself?)

2.3 How do you eat soft porridge?

Stiff porridge?

Meat?

Chicken?

Vegetables?

Samp and beans?

Dumpling?

2.4 If you have cooked samp and beans or rice, will you also cook pap and eat it at the same meal?

2.5 How many vegetables do you eat at a meal during the week. If you have cabbage will you also have pumpkin or will you just have cabbage alone or pumpkin alone?

2.6 How many vegetables do you eat at your Sunday meal?

3. **Portion sizes**

3.1 Ask participants to work in pairs to serve a typical weekday meal for:
a male, a female, a teenage boy, a teenage girl.

3.2 When they have done this, everyone looks at the servings and discusses them until they reach agreement on serving sizes.

3.3 As a group, dish up rice for a man, a woman, a teenage boy and teenage girl.

3.4 As a group, dish up canned peaches and custard for a man, a woman, a teenage boy and a teenage girl.

4. Sweets and chocolates

What sweets do you usually buy?

What chocolates do you usually buy?

How much sweets and chocolates do you eat at a time?

5. Do you cook like your mother or grandmother?

If yes, what in particular do you cook in the same way?

If no, what do you do differently?

6. What foods do you cook on the hot plate and what in the lapa?

THANK YOU ALL VERY MUCH FOR YOUR HELP. PLEASE HAVE SOME REFRESHMENTS.

While participants are having refreshments, weigh and record serving sizes.

APPENDIX D

RECIPE FORM

Subject Number: _____
Date: _____
Area: _____

Recipe number: _____

Name of dish: _____

Number of persons who can eat from this: _____

Code	Ingredient	Household measure	Weight/ Volume

Describe method:

APPENDIX E
RESPONSE FORM
EVALUATION OF FOOD PHOTOGRAPHS

Subject Number: _____ Gender M F Age _____ Date _____
 Highest education level :

No schooling	1
Grade 1- Std 2	2
Std 2 - Std 5	3
Std 6 - Std 8	4
Std 9 - Std 10	5
Post matric	6

INTERVIEWER INSTRUCTIONS: Show the subject the actual food first and then the photograph of the food portion sizes. Each portion size is labelled A, B, C or D. Ask the subject which photograph is the same size as the actual food. Write the letter of the subject's choice in the column next to the food name. The portion size may be the same as the photograph or it may be smaller than A, between A & B, B & C, or bigger than C. For stiff porridge and samp and beans the size may be between C & D or bigger than D. Use the following codes for sizes between the photographs.

DO NOT TELL THE SUBJECT THE ANSWERS.

Smaller than A A- Between A & B AB
 Between B & C BC Bigger than C C+
 Between C & D CD Bigger than D D+

FOOD	PORTION SIZE	ANSWER	WEIGHT	COR/INCOR
Stiff porridge				
Soft porridge				
Samp and beans				
Rice				
Steak				
Stew				
Boerewors				
Pilchards whole				
Pilchards mashed				
Fried fish				
Cabbage				
Spinach				
Tomato and onion				
Pumpkin				
Beetroot				
Apples				
Dumpling				
Bread with spread				
Bread				
Vetkoek				

APPENDIX F**DIETARY INTAKE INTERVIEW SCHEDULE**

SUBJECT NUMBER _____

INTERVIEWER _____

INTRODUCTION:**Greeting**

Thank you for giving up your time to participate in this study. I hope you are enjoying it so far. Here we want to find out what people living in this area eat and drink. This information is important to know as it will tell us if people are eating enough and if they are healthy.

Please think carefully about the food and drink you have consumed during the past few months. I will now go through a list of foods and drinks with you and I would like you to tell me:

- if you eat the food
- how the food is prepared
- how much of the food you eat at a time
- how many times a day you eat it and if you do not eat it every day, how many times a week or a month you eat it

To help you to describe the amount of a food you eat, I will show you pictures of different amounts of the food. Please say which picture is the closest to the amount you eat, or if it is smaller, between sizes or bigger than the pictures.

I will also ask some questions about where you get your food, where you shop, whether you eat away from home and so on. This information is important because it will tell us which foods are easy to obtain and which are not and how the food is prepared and served.

THERE ARE NO RIGHT OR WRONG ANSWERS.

EVERYTHING YOU TELL ME IS CONFIDENTIAL. ONLY YOUR SUBJECT NUMBER APPEARS ON THE FORM.

IS THERE ANYTHING YOU WANT TO ASK NOW?
ARE YOU WILLING TO GO ON WITH THE QUESTIONS?

DEGREE OF ACCULTURATION:

INTERVIEWER:

DATE:

Subject Number				
Area				

INSTRUCTIONS: Circle the number next to the subject's answer.

1. Were you born in this area?

Yes	1	No	2
-----	---	----	---

1.1. If NO, how long have you lived in this area?

< 1 year	1
1 - 2 years	2
3 - 5 years	3
6 - 10 years	4
11 - 15 years	5
16 - 20 years	6
>20 years	7
Not applicable	8

Instruction: If subject answered NO to question 1 or has lived in the area for 10 years or less ask questions 2.1 and 2.2.

If subject was born or has lived in this area for more than 10 years, go to question 3 (rural and farm areas) or question 4 (township and city areas)

2.1 Where did you live immediately before you came here?

--	--

2.2 What type of area was this?

Rural villages	1
White owned farm	2
African owned farm	3
Informal settlement (Squatter)	4
Township, Town or City	5
Not applicable	6

3. To be answered by subjects living in Informal Settlements and Urban areas:

3.1 Do you have relatives living in villages and/or farms?

Yes	No	Don't know
1	2	3

3.2 If yes, when did you last visit them?

less than 1 year ago	1
1 - 2 years ago	2
3 - 4 years ago	3
5 or more years ago	4
Never	5
Not applicable	6

3.3 How many times a year (from Christmas to Christmas) do you visit?

1 - 3	1
4 - 6	2
7 - 9	3
10 - 12	4
more than 12	5
Never	6
Not applicable	7

4. To be answered by subjects living in rural and farm areas:

4.1 Do you have relatives living in urban areas?

Yes	No	Don't
1	2	know 3

4.2 If YES, when did you last visit them?

less than 1 year ago	1
1 - 2 years ago	2
3 - 4 years ago	3
5 or more years ago	4
Never visit	5
Not applicable	6

4.3 How many times a year (from Christmas to Christmas) do you visit?

1 - 3	1
4 - 6	2
7 - 9	3
10 - 12	4
more than 12	5
Never visit	6
Not applicable	7

PART I

INSTRUCTIONS: Circle the number next to the subject's answer
OR write the time in the columns.

SUBJECT NO _____

EXAMPLE:

1. How many meals did you eat a yesterday? Yesterday=Mon1 Tues2 Wed3 Thurs4 Fri5 Sat6 Sun7					
2.1.1 At about what time did you eat your first meal?					
2.1.2 Where did you eat this meal?					
Home					1
Work					2
Other specify:					3
Not applicable					4

Please answer the following questions:

1. How many meals did you eat a yesterday? Yesterday=Mon1 Tues2 Wed3 Thurs4 Fri5 Sat6 Sun7					
2.1.1 At about what time did you eat your first meal?					
2.1.2 Where did you eat this meal?					
Home					1
Work					2
Other					3
Not applicable					4
2.2.1 At about what time did you eat your second meal?					
2.2.2 Where did you eat this meal?					
Home					1
Work					2
Other					3
Not applicable					4
2.3.1 At about what time did you eat your third meal?					
2.3.2 Where did you eat this meal?					
Home					1
Work					2
Other					3
Not applicable					4
2.4.1 At about what time did you eat your other meals?					
2.4.2 Where did you eat these meals?					
Home					1
Work					2
Other					3
Not applicable					4
2.5 Do you eat this number of meals on most week days?				Yes 1	No 2
IF NO:					
2.5.1 How many meals do you usually eat a day Not applicable=99					
2.6 Do you eat your meals at about the same times as above on most days?				Y 1	N 2
IF NO:					
2.6.1 At about what time do you usually eat your first meal?					

[illegible]

INSTRUCTION: If subject answers YES to question 3, ask 3.2; if answer is NO, ask 3.3								
3.2 Do you eat or drink anything between meals on most days?					Yes 1		No 2	
3.2.1 If YES: what do you usually eat or drink and when and where do you eat it?								
Type of food	When?	Where?						
3.3 Although you did not eat anything between meals yesterday, do you eat or drink anything between meals on most days?					Yes 1		No 2	
3.2.1 If YES: what do you usually eat or drink and where and when did you eat it?								
Type of food	When?	Where?						

4. How is food served at most meals in your family?

Mother serves all onto each person's own plate	1
Each serves self onto his/her own plate	2
Father serves all onto each person's own plate	3
Adults serve themselves and children	4
All eat from common bowl	5
Adults and children eat from separate common bowls	6
Adults eat from plates, children from common bowl	7
Other (Describe eg lives alone; lives in hostel)	8

SUBJECT NUMBER PART II

INSTRUCTION: Circle the subject's answer. Fill in the amount and times eaten in the appropriate columns.

I shall now ask you about the type and the amount of food you have been eating in the last few months. Please tell if you eat the food, how much you eat and how often you eat it. We shall start with maize meal porridge.

Do you eat maize meal porridge? YES 1 NO 2
 If YES, what type do you have at home now?
 Brand name _____
 Don't know 2
 Grind self 3

If brand name given, do you usually use this brand
 YES 1 NO 2 DON'T KNOW 3

Where do you get your maize-meal from ? (May answer more than one)
 Shop 1
 Employer 2
 Harvest and grind self 3
 Other - specify 4
 Don't know 5

FOR OFFICE USE

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/DAY
			Per day	Per week	Per month	Seldom Never		
Maize-meal porridge	Stiff (pap)						e4225 4250	
Maize-meal porridge	Soft (slap pap)						e4225 4250	

Do you pour milk on your soft porridge ? YES NO
 If YES, what type of milk (whole fresh, sour, 2%, fat free, milk blend,) _____

INSTRUCTION: Show subject examples.

If YES, how much milk?							
Do you pour sugar on your soft porridge ? YES 1 NO 2							
If YES, how much sugar?							9012
Maize-meal porridge	Crumbly (phutu)						e4225 4250
Ting							
Mabella Coarse Fine Rice	Stiff						4082
Mabella Coarse Fine Rice	Soft						4082

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/DAY
			Per day	Per week	Per month	Seldom Never		
Do you pour milk on your mabella porridge ? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2%, fat free, milk blend,) _____ INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your mabella? YES 1 NO 2								
If YES, how much sugar?							9012	
Oats							4032	
Do you pour milk on your oats? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2%, fat free, milk blend,) _____ INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your oats? YES 1 NO 2								
If YES, how much sugar?							9012	
Breakfast cereals	Brand names of cereals at home now: Don't know _____						4036	
Do you pour milk on your cereal? YES 1 NO 2 If YES, what type of milk (whole fresh, sour, 2%, fat free, milk blend,) _____ INSTRUCTION: Show subject examples.								
If YES, how much milk?								
Do you pour sugar on your cereal? YES 1 NO 2								
If YES, how much sugar?							9012	
Samp	Bought Self ground with fat without fat						4043	
Samp and beans							A014	
		Are the amounts of samp and beans the same as in the picture? Y N If no, do you use more beans than in the picture or less? More Less						
Samp and peanuts							A013	
		Are the amounts of samp and peanuts the same as in the picture? Y N If no, do you use more peanuts than in the picture or less? More Less						
Rice	White Brown Maize rice						4040 4134 4043	
Pastas	Macaroni Spaghetti Other:						4062	
You are being very helpful. Can I now ask you about meat? CHICKEN, MEAT, FISH Where do you get your chicken from? (May answer more than 1) Shop supermarket spaza Employer Slaughter own Gift Other specify: Do not eat chicken								1 2 3 4 5 6

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/DAY
			Per day	Per week	Per month	Seldom Never		
Chicken:	Boiled, nothing added						1521	
	Fried: in batter/crumbs Not coated						1634 1520	
	Roasted grilled						1520	
	Stewed						A002	
	What vegetables are in the stew?							
Don't know								
Do you eat chicken skin Always 1 Sometimes 2 Never 3								
Chicken bones stew							A003	
Chicken feet	How do you cook it?						A004 1609	
Chicken offal	How do you cook it?						1610	
Where do you get your MEAT from? (May answer more than 1) Shop supermarket spaza Employer Slaughter own Gift Other specify: Do not eat red meat								1 2 3 4 5 6
Red meat:	How do you like meat? With fat Fat trimmed							
Beef	Fried - with bone							
	Fried - without bone							
	Stewed - with bone						A001	
	Stewed - without bone						A001	
	Grilled - with bone							
	Grilled -without bone							
	Minced						1585	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/DAY
			Per day	Per week	Per month	Seldom Never		
Mutton	Fried - with bone						1522	
	Fried - without bone						1571	
	Stewed - with bone						1511	
	Stewed - without bone						1511	
	Grilled - with bone							
	Grilled - without bone							
	Minced						1662	
Pork	Fried - with bone							
	Fried - without bone							
	Stewed - with bone							
	Stewed - without bone							
	Grilled - with bone							
	Grilled - without bone							
Beef Offal	Intestines: boiled, nothing added						1616	
	stewed with vegetables							
	Tripe						1546	
	Heart						1565	
	Lungs							
	Liver						1515	
	Kidneys						1518	
	Other specify:							
What vegetables are usually put into meat stews?								
Wors sausage	Fried						1526	
	Grilled							
Bacon							1501	
Cold meats	Polony						1514	
	Ham						1564	
	Viennas						1531	
	Other - specify							
Canned meat	Bully beef						1535	
	Other specify:							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	Amount/day
			Per day	Per week	Per month	Never		
Meat pie	Home made Bought						1548	
Hamburger	Home made Bought						A015	
Dried beans/peas lentils(10)	How do you prepare them?							
Soya products eg Toppers	Brands at home now Don't know _____ Show examples						3527	
Pilchards in tomato/chilli/brine	Whole						2557	
	Mashed with fried onion						A005	
Fried fish	With batter crumbs						2523	
	Without batter/crums						2509	
Other canned fish	Tuna						2547	
	Pickled fish Other:						2562	
Fish cakes	Homemade (describe)						2531	
	Frozen Bought							
EGGS	Boiled poached						1001	
	Scrambled						1025	
	Fried						1003	

WE NOW COME TO VEGETABLES AND FRUIT

Where do you get your vegetables from (may answer more than 1)

Own vegetable garden	1
Employer's farm	2
Own farm	3
Shops Supermarket greengrocer	4
Hawker	5
Veld (eg morogo)	6
Gifts	7
Other (describe)	8

FOOD	DESCRIPTION	Amt	TIMES EATEN Seldom				CODE	AMOUNT/DAY
			Per day	per week	Per Month	Never		
Cabbage	How do you oook cabbage?							
	Boiled, nothing added						8066	
	Boiled with potato and onion and fat						A006	
	Fried, nothing added						A007	
	Boiled, then fried with potato, onion						A006	
	other: Don't know							
Spinach/ morogo/ other green leafy	How do you oook spinach?							
	Boiled, nothing added						8071	
	Boiled fat added						8209	
	Boiled with- onion /tomato and fat						A011	
	- onion, tomato & potato						8212	
	- with peanuts							
	other: Don't know							
Tomato and onion 'gravy'	Home made-with fat -without fat						A012 A016	
	Canned {Is this the amount of pap you eat? How much more or less}						8221	
Pumpkin	How do you oook pumpkin?							
	Cooked in fat & sugar						A010	
	Boiled, little sugar and fat						A009	
	Other _____							
	Don't know _____							
Carrots	How do you oook carrots?							
	Boiled , sugar & fat						8129	
	With potato/onion						A008	
	Raw, salad Chakalaka						8015 A025	
	Other _____							
	Don't know _____							

FOOD	DESCRIPTION	Amount	TIMES EATEN Seldom				CODE	AMOUNT/DAY
			Per day	per week	Per Month	Never		
Mealies/ Sweet corn	How do you eat mealies? On cob-with fat - without fat						8033	
	Off cob - with fat -without fat						8261	
Beetroot salad	Home made Bought						8005	
Potatoes	How do you cook potatoes?							
	Boiled/baked-with skin						8046	
	- without skin						8045	
	Mashed						8187	
	Roasted						8189	
	French Fries						8048	
	Salad Other:						8236	
Sweet potatoes	How do you cook sweet potatoes?							
	Boiled/baked-with skin						8057	
	- without skin						8214	
	Mashed						8058	
	Other: Don't know							
Salad vegetables	Raw tomato,						8059	
	Lettuce,						8031	
	Cucumber						8025	
Other vegetables specify:								

FRUIT:

Do you like fruit?

YES

NO

Where do you get your fruit from?

Own fruit trees	1
Farm - employer	2
Farm - own	3
Supermarket/greengrocer	4
Hawker	5
Veld	6
Gifts	7
Other	8

FOOD	DESCRIPTION	Amount	TIMES EATEN Seldom				CODE	AMOUNT/DAY
			Per day	per week	Per Month	Never		
Apples/Pears	Fresh						7001	
Pears	Fresh Canned						7053 7054	
Bananas							7009	
Oranges / naartjie							7031	
Grapes							7020	
Peaches	Fresh Canned						7036 7038	
Apricots	Fresh Canned						7003 7004	
Mangoes	Fresh						7026	
Guavas	Fresh Canned						7021 7023	
If subject eats canned fruit: Do you have custard with canned fruit ? Yes 1 No 2								
Custard	Home made Ultramel						0004	
Wild fruit/berries	Stamvrugte Noem-noem Klappers Maroelas Nastergals Other -specify						7070	
Dried fruit:	Types:							
Other fruit:								
BREAD AND BREAD SPREADS								
Bread Bread rolls	White						4001	
	Brown						4002	
	Whole wheat						4003	
Do you spread anything on the bread? Always 1 Sometimes 2 Never 3 If YES, what do you spread ?								
Margarine	What brand do you have at home now? Don't know Show examples						6508 6521	

FOOD	DESCRIPTION	Amount	TIMES EATEN Seldom				CODE	AMOUNT/DAY
			Per day	per week	Per Month	Never		
Butter	What brand do you have at home now? _____ Home made Don't know						6502	
Peanut butter							6509	
Jam/syrup/honey							9008	
Marmite/Fray Bentos etc							9501	
Fish/meat paste							1512	
Cheese	Type:						0010	
Atchar							3004	
Polony							1514	
Other spreads: specify								
Dumpling							4001	
Vetkoek							4057	
Provita, crackers etc								
FATS: What fats do you use and where do you use them?								
Margarine	Where used: on bread							
	with vegetables** Number of spoons _____ /number in family _____							
Butter	on bread							
	with vegetables** Number of spoons _____ /number in family _____							
Holsum /vegetable fat	Where used: Number of spoons _____ /number in family _____						6508	
Oil	Where used: Number of spoons _____ /number in family _____						6510	
Dripping	Where used: Number of spoons _____ /number in family _____							
Mixed fat (makhuru)	Where used: Number of spoons _____ /number in family _____							
Lard	Where used: Number of spoons _____ /number in family _____						6520	

[illegible]

FOOD	DESCRIPTION	Amount	TIMES EATEN Seldom				CODE	AMOUNT/DAY
			Per day	per week	Per Month	Never		
Milk/cup coffee	What type of milk do you use in coffee?							
	Fresh/long life whole						0006	
	Fresh/long life 2%							
	Fresh/long life fat free						0072	
	Whole milk powder brand						0009	
	Skimmed milk powder Brand						0008	
	Milk blend Brand						0068	
	Whitener Brand						0039	
	Condensed milk						0002	
	Evaporated milk						0003	
	None							
Milk as such	What type of milk do you drink as such?							
	Fresh/long life whole						0006	
	Fresh/long life 2%							
	Fresh/long life fat free						0072	
	Sour / Maas						0006	
	Buttermilk						0001	
	Whole milk powder Brand						0006	
	Skimmed milk powder Brand						0072	
	Milk blend Brand						0068	
Milk drinks Brand	Nestle Milo Other						0023	
Yoghurt	Drinking yoghurt Thick yoghurt						0044 0020	
Squash	Sweeto SixO Oros/Lecol-with sugar - artificial sweetener Kool Aid Other						9013 9013 9002 9013 9002	
Fruit juice	Fresh/ Liquifruit/Ceres Tropica Concentrates eg Halls Nectars Flavour:							

FOOD	DESCRIPTION	Amount	TIMES EATEN Seldom				CODE	AMOUNT/DAY
			Per day	per week	Per Month	Never		
Fizzy drinks Coke, Fanta	Sweetened Diet						9001 9013	
Mageu /Motogo							9562	
Home brew							9516	
Tlokwe							9516	
Beer							9506	
Spirits							9510	
Wine red							9508	
Wine white							9518	
Liqueur							9517	
Other: specify								
SNACKS AND SWEETS:								
Potato crisps							4275	
Cheese curls Niknaks etc							4067	
Peanuts	Raw Roasted						6001 6007	
Raisins							7022	
Peanuts and raisins								
Chocolates	Name						9024	
Candies	Sugas, gums, hard sweets						9009	
Sweets	Toffees, fudge, caramels						9014	
Biscuits	Type							
Cakes & tarts	Type							
Scones							4029	
Rusks							4160	
Savouries	Sausage rolls Samoosas Biscuits eg bacon kips Other:						1534 4196 4162	

[illegible]

SALT USE:

The next few questions are to find out if you use salt, where you use it and how much you use?

Do you add salt to food while it is being cooked?

Always 1	Sometimes 2	Never 3	Don't know 4
-------------	-------------	------------	-----------------

Do you add salt to your food after it has been cooked?

Always 1	Sometimes 2	Never 3	Don't know 4
-------------	-------------	------------	-----------------

Do you like salty foods eg salted peanuts, crisps?

Very much 1	like 2	Not at all 3	
----------------	--------	-----------------	--

KEEPING FOOD:

Do you keep food from one meal to eat at the next meal?

Always 1	Sometimes 2	Never 3	Don't know 4
-------------	----------------	------------	-----------------

If ALWAYS OR SOMETIMES, what foods do you keep ?
Do you eat kept food cold or do you reheat it?

FOOD	Reheated	Eaten Cold

Do you use any of the following?

	Name of product	Amount/d ay
Vitamins/ vitamins & minerals		
Tonics		
Health foods		
Body building preparations		
Dietary fibre supplement		
Other: specify		

THANK YOU FOR YOUR COOPERATION AND PATIENCE

GOOD-BYE!

APPENDIX G

INFORMED CONSENT FORM COMPLETED BY ALL THUSA VOLUNTEERS

INFORMED CONSENT : THUSA PROJECT

Title of the project: Nutritional status and disease risk of Africans in transition

I, the undersigned.....
(full names in print), have read the details of the project or, have listened to the oral explanation thereof, and declare that I understand it. I have had the opportunity to discuss relevant aspects with the researcher and declare that I voluntarily participate in the project. I hereby give consent to participate in the project.

.....
Signature of volunteer

Signed aton.....

Witnesses

.....

Signed aton.....

For subjects under the age of 21, signed consent of a parent or legal guardian is necessary.

I, (full names) the parent/legal guardian of the person named above, hereby consent that he/she may participate in the THUSA project.

Signature Date

Relationship

Address and telephone number of volunteer:

.....
.....
.....
.....

OFFICE USE:

APPENDIX H

ANTHROPOMETRIC DATA COLLECTION SHEET

Subject number					
Area					
Date	m	m	d	d	y y
Date of birth					
Age (years)					
Sex					M F

Weight Kg				.	
Height Cm				.	

Waist Cm				.	
Hip Cm				.	

Subscapular skin-fold mm1				.	
2				.	
3				.	

Triceps skin-fold mm1				.	
2				.	
3				.	

APPENDIX I

**SUBJECT INFORMATION FOR
FOR REPEAT QFFQ INTERVIEWS AND WEIGHED RECORDS**

Subject number : _____ **Date** ____/____/____
Name: _____
Area: _____ **Day of week** _____
Gender: M____ F____

Address _____

Tel no: _____(h)_____(w)

Directions to home: _____

Name and address of another contact person: (friend, neighbour, relative, employer)

Tel no _____

Date for visit _____

APPENDIX J

SEVEN-DAY WEIGHED RECORD*

CONFIDENTIAL

SUBJECT NUMBER _____

THUSA

Transition, Health and Urbanisation in South Africa

FOOD DIARY

***Note:** Recording sheets are only shown for Day 1. The sheets for Day 2 to Day 7 were the same as for Day 1.

INSTRUCTIONS

1. Please use this booklet to write down everything you eat or drink for the following seven days :
-

As you will see, each day is marked into sections, beginning with the first thing in the morning and ending with bedtime. For each part of the day write down everything that you eat or drink, how much you eat or drink, and a description if necessary. If you do not eat or drink anything during that part of the day, draw a line through the section.

2. You have been provided with : a scale to weigh food, a measuring jug to measure liquids and a set of measuring spoons to measure small amounts of foods and liquids..
3. Write down everything at the time you eat or drink it. Do not try to remember what you have eaten at the end of the day.
4. Before eating or drinking, the **prepared** food or drink must be weighed or measured and written in the record book. If you do not consume all the food or drink, what is left must also be weighed or measured and recorded in the book.
5. Please prepare foods and drinks as you always do. Also eat and drink in the same way as normal: eat the foods and drink in the amounts and at the times that you always eat and drink. Try not to change the way you eat and drink at all.
6. We need to know **ALL** the food and drink you take during these seven days. So if you eat away from home, (eg at work, with friends, at a cafe or restaurant) please take your measuring equipment with you so you can still measure your food. Also do not forget to measure food bought at take aways.
7. Please write down the recipes of homemade dishes such as stews, soups, cakes, biscuits or puddings. Also say how many people can eat from them or how many

biscuits or cakes you get from the recipe.

8. On the next page is a list of popular foods and drinks. Next to each item is the sort of thing we need to know so that we can tell how it is made and how much you had. This list does not contain all foods, so if a food that you have eaten is missing, try to find a food that is similar to it. Please tell us as much about the food as you can.
9. Please tell us the amount and type of oil or fat that you use for cooking, frying or baking
10. Most packet and tinned foods, like Simba chips, Niknaks, corned meat, tinned pilchards have weights printed on them. Tins, bottles and boxes of cold drinks and alcoholic drinks also have weights printed on them. Please use these to show us how much you ate or drank. When possible, please keep the empty packets, bottles or tins.

PLEASE NOTE: we need to know the amount YOU eat or drink. So, if you do not eat the whole packet or tin of food, or drink the whole bottle of cold drink, please measure the amount you eat or drink.

11. At the end of each day there is a list of snacks and drinks that can easily be forgotten. Please write any extra items in here if you have not already written them down in some part of the day.
12. The research assistant will visit you during the record days to help you if you have any questions or problems. She will collect the equipment and record book after the three days.

ALL THE INFORMATION YOU GIVE US IS STRICTLY CONFIDENTIAL. IT WILL ONLY BE USED FOR RESEARCH PURPOSES. ONLY YOUR SUBJECT NUMBER APPEARS ON THE RECORD BOOK. NOBODY WILL BE ABLE TO IDENTIFY YOU WITH THE RECORD BOOK.

FOOD/DRINK	DESCRIPTION AND PREPARATION	AMOUNT
Atchar	Homemade or brand name	Weight or number of measuring spoons
Beer	What sort: Tlokwe; homemade; Brand name e.g. Lion, Castle, Black Label. If homemade, please give recipe.	Number and size of bottles, cans, mugs or glasses
Biscuits	What sort; homemade. Please give recipe	Number and size
Bread spreads	Type eg margarine, peanut butter, jam, atchar	Number of measuring spoons
Bread	White, brown, whole wheat; bread or bread rolls or buns.	Weight and number of slices
Breakfast cereals	Name eg Kelloggs All Bran, Rice Crispies	Weight
Cheese	What sort: cheddar, Gouda, cottage, cream; wedges, spread	weight, number
Chicken	Boiled, fried, roasted, grilled or stewed. Part of the chicken eaten eg breast, wing Skin eaten or not	Weight - say whether with or without bone
Chocolates	Name e.g. Nestle milk chocolate, Bar-One, Tex	Number or weight on packet
Cold drinks	What sort e.g. Sweeto, SixO; Coke, Fanta; fruit juice; sweetened or diet	Volume of glass or size of bottle or tin
Dumpling	Type of flour used. Please give the recipe	Weight
Eggs	Boiled, poached, fried, scrambled. If fried or scrambled, the amount and type of fat used.	Number
Fat cakes	Size. Please give the recipe.	Weight and number
Fat	Type eg dripping, beef fat, Holsum	Weight or measuring spoons
Fresh fruit	What sort, with or without skin	Size and number or weight
Fried fish	Bought or home-made; with or without coating	Weight
Homemade dishes	Please say what the dish is called and give the recipe or ingredients	Weight
Mabella	Fine or course. Name of mabella used. Stiff or soft. Salt added or not. Please keep a sample of mabella	Weight
Margarine	Name, hard, soft or medium fat	Weight or measuring spoon

FOOD/DRINK	DESCRIPTION AND PREPARATION	AMOUNT
Mealie-meal porridge	Name of mealie-meal used. Crumbly, very stiff, stiff, medium stiff, soft, very soft, mageu. Weigh the amount of meal and measure the amount of water used to make the porridge. Salt added or not. Please keep a sample of porridge.	Weight
Meals eaten away from home	What sort e.g. fish and chips, steak, hamburger, chicken, bread and chips, Please say what the dish is called and give ingredients if possible. Give the name of the restaurant or take away.	Weight, or table spoons
Meat	What sort, fatty or not. Fat cut off or not. How cooked eg boiled, fried, stewed. With or without bone. Cooked with or without vegetables.	Weight - say whether with or without bone
Milk - in tea /coffee	What sort: fresh, milk powder - give name, whitener - give name, condensed milk	Number of spoons or volume
Milk to drink or on porridge or cereals	What sort: fresh, milk powder - give name, whitener - give name, condensed milk	Number and size of cups/glasses
Oil	Name	Measuring spoons
Other porridge	Name. Salt added or not	Weight
Polony	Type	Weight or thickness of slice
Pudding	What sort and brand, e.g. jelly, tinned fruit, instant pudding, baked pudding, custard, give recipe	Weight or volume
Ready-made dishes	What sort e.g. pizzas, pies, frozen foods. Please keep the containers	Weight
Rice	Type of rice.	Weight
Salt, pepper		Measuring spoons
Samp Samp and beans	Name of samp. Type of fat added. Number of cups of samp and beans used. Type of beans used.	Weight
Sauces	Tomato sauce, worcester sauce, mustard sauce, chutney	Number of size of spoons
Snacks in packets	What sort e.g. Simba chips, cheese curls, Niknaks, peanuts	Weight of packet
Soya	Name eg Toppers, Imana, Woza	Weight
Spirits	What sort e.g. brandy, cane, gin, whisky; type of mixer e.g. coke, tonic, soda water	Number of tots or glasses

FOOD/DRINK	DESCRIPTION AND PREPARATION	AMOUNT
Sugar - in tea /coffee	What sort: white or brown	Number and size of measuring spoons
Sweets	What sort: e.g. toffees, hard sweets, liquorice all sorts, marshmallows	Number
Take away	What sort e.g. fish and chips, steak, hamburger, chicken. Please say what the dish is called and give ingredients if possible. Give the name of the take-away	Weight
Tea / Coffee	What sort	Size and number of cups/mugs
Ting	Mealie-meal or mealie meal and mabella Salt added or not Please keep a sample of ting	Weight
Tinned fruit	What sort. With or without custard	Weight of fruit Volume of custard
Tinned fish	Type, straight from tin or mixed with onion and/or tomato	Weight
Vegetables	What sort, how cooked eg fried, boiled, with potato and onion, with fat	Weight
Wine, sherry, port, liqueurs	White, red, sweet, dry	Number and size of glasses

EXAMPLE

Breakfast			Office use		
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code
Mealie meal porridge	Iwiza. Soft, 1 cup meal and 3 cups water	300g	-		
Milk	Fresh, full cream Clover	300ml			
Bread	Brown	1x60g			
Margarine	Rama, soft	10 ml			
Tea	Glenn tea bags	1 cup			
Milk	Fresh full cream Clover	25 ml			
Sugar	White	2 heaped teaspoons			

DAY No 1					
DATE __/__/1996			DAY OF WEEK _____		
EARLY MORNING - BEFORE BREAKFAST				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code
BREAKFAST				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code
MID MORNING - BETWEEN BREAKFAST AND LUNCH TIME				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code

LUNCH TIME				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code
MID AFTERNOON - BETWEEN LUNCH AND DINNER				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code

DINNER TIME				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code
LATE NIGHT - up to last thing at night				Office use:	
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code

Between meals, snacks and drinks if not already written in before					
Food/Drink	Description and Preparation	Amount served	Amount left	Amount eaten	Code
Sweets and chocolates					
Biscuits or cakes					
Simba chips					
Peanuts					
Other snacks					
Cold drinks					
Beer					
Tlokwe					
Mageu					
Other drinks					
Tea					
Coffee					
Milk					
Anything else?					
Please write in the recipes or ingredients of any homemade dishes, take aways that you have written in but not already described:					

END OF DAY No 1

APPENDIX K**24-HOUR URINE COLLECTION INSTRUCTION AND RECORDING SHEET****The THUSA project**
INSTRUCTIONS FOR URINE COLLECTION

1. All urine passed over a 24-hour period must be collected using the bottles provided.
2. Do not collect the first urine passed on the day of collection (day:_____). BUT write down the time on the record sheet (for example 0600)
3. Pin the safety pin onto the front of your under wear. This is to remind you to collect your urine.
4. Take one PABA tablet in the morning (immediately after passing urine), one in the middle of the day (at lunch time) and one in the evening (at dinner time).
NOTE: These tablets are completely harmless. They will not have any effect on you. They are only taken to mark the urine and are completely passed out of the body with the urine.
5. Write down the time each PABA tablet is taken on the record sheet.
6. Collect all urine passed for the next 24 hours including the first urine passed the next morning.
Write down the time each time you pass urine.
7. Keep the bottles in the bag provided.
8. Write down any problems you experience on the record sheet.
9. The research assistant will collect the bottles from you on _____.

THANK YOU VERY MUCH FOR YOUR COOPERATION

