Relationship of salt usage behaviours and urinary sodium excretion in normotensive South African adults

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Abstract

Background: Dietary salt intake in the South African population exceeds the physiological need. Excessive salt intake is associated with elevated blood pressure levels which may lead to hypertension and cardiovascular accidents. A lifestyle modification such as dietary salt restriction is an inexpensive, effective disease prevention option.

Objective: The overall main objectives of this investigation was to: 1) compare salt intake, estimated from a short salt frequency intake questionnaire, with the 24-hour urinary salt excretion and blood pressure of young normotensive healthy white and black South Africans; and 2) compare 24-hour salt excretion and 24-hour blood pressure profiles of normotensive white and black individuals in terms of their knowledge, attitude and behaviour towards dietary salt intake.

Study design: The study design was cross-sectional and nested in the baseline phase of the African Prospective Study on the Early Detection and Identification of Cardiovascular Disease and Hypertension in South Africa (African-PREDICT) study.

Methods: Multiple methods of data collection were used including anthropometry, biochemical analyses, dietary intakes and cardiovascular measurements. Participants in the study completed the short salt frequency intake questionnaire, describing and quantifying habitual salt intake, and a questionnaire describing knowledge, attitude and behaviour regarding salt intake. Responses to the questionnaires were compared with actual salt intakes estimated from a single 24-hour urine sample and with the 24-hour blood pressure measurements.

Results: There was no significant correlation between salt intake based on the questionnaire and 24-h urinary excretion in the white (r=0.07; p=0.40) and black (r=-0.53; p=0.56) participants before and after adjustment for covariates. Estimated salt intake from the questionnaire significantly correlated with systolic blood pressure in white participants (r=0.22, p=0.005) before adjustment for covariates and was no longer significant after adjustment. None of the correlations (unadjusted or adjusted) were significant for the black participants (all p>0.05). The Bland-Altman plots for salt intake showed that the mean difference between the methods used to determine salt intake for the white group is 0.5 g/day, and for the black group is -1.9 g/day. The urinary salt excretion may estimate salt intake to be 9.6 g/day above or 11.1 g/day below the questionnaire's estimation in the white, and 10.8 g/day above and 18.4 g/day below in the black groups. The level of agreement (Cohen's Kappa analyses) between the salt frequency questionnaire and the 24-hour urinary salt excretion were determined by categorising the participants in groups who meet the target of <5 grams salt per day or do not. The value of Kappa for the white participants was 0.17 (slight agreement) and for the black participant it was

-0.06 (no agreement). In the white participants were a significant increase in both SBP and DBP with increasing tertiles of salt intake according to the questionnaire (p<0.006 and p<0.02 respectively). In the black participants there were no significant difference in BP levels (all p>0.05).

The five foods/food groups that contributed most to dietary salt intake in both ethnic groups were discretionary salt, bread, gravy made with stock or gravy powder, soup and biltong. There were no differences in the BP levels between those who answered questions about their knowledge and attitude towards salt intake in both ethnic groups (all p>0.05). Also, there were no differences in their urinary salt excretion (all p>0.05). Only certain behaviours mentioned in the questionnaire were reflected in the salt intake levels and blood pressure.

Conclusions: The short salt frequency intake questionnaire can be used to identify food items that contribute to total salt intake. However, the questionnaire considerably underestimates the dietary salt intake. The application of this questionnaire may be helpful in epidemiological studies that evaluate foods which contribute to the total salt intake in order to monitor the average salt intake of a population and to assess the proportion of the population that does not meet the target of less than 5 grams of salt intake per day. It cannot, however, be used to assess the salt intake of an individual.

The knowledge, attitude and behaviour of women and men of both ethnic groups are poorly reflected in their actual salt intake and blood pressure, especially among the black participants. The majority of the participants in both ethnic groups consume dietary salt in much higher quantities than the recommended less than 5 grams per day.

The current public awareness campaign to decrease salt intake to the target level of less than 5 grams per day by the South African National Department of Health and the Heart and Stroke Foundation is commendable.

Key terms: Salt, Sodium, Urinary sodium excretion, Knowledge, Attitude, Behaviour, Salt frequency intake, Questionnaire

Opsomming

Agtergrond: Die inname van sout in die Suid-Afrikaanse populasie is hoër as wat die fisiologiese behoefte vereis. Hoë inname van sout word geassosieer met verhoogde bloeddruk vlakke wat kan lei tot hipertensie en kardiovaskulêre insidente. Lewenstyl modifikasie soos die beperking van sout inname is ŉ goedkoop en effektiewe voorkomings opsie.

Doelwit: Die hoof doelwitte van hierdie projek was om: 1) sout inname te valideer vanaf ŉ kort sout frekwensie vraelys in vergelyking met die 24 uur sout ekskresie *via* uriene asook bloed druk van jong, gesonde normotensiewe blank en swart Suid-Afrikaners; en 2) om die 24 uur sout ekskresie en 24 uur bloed druk profiele te vergelyk in normotensiewe blank en swart individue in terme van hul kennis, gesindheid en gedrag teenoor dieet sout inname.

Studie ontwerp: Die studie ontwerp was ŉ deursnit studie ontwerp gebaseer op die basislyn fase van die African-PREDICT studie wat kyk na die identifisering van risikofaktore en geassosieerde vroeë merkers in die ontwikkeling van kardiovaskulêre siektes in 'n kohort Suid Afrikaners.

Metode: ŉ Verskeidenheid bronne van data kolleksie was gebruik en dit sluit in antropometrie, biochemiese analises, dieet innames en kardiovaskulêre metings. Deelnemers aan die studie het ŉ kort sout frekwensie vraelys ingevul wat die kennis, gesindheid en gedrag in terme van sout inname gemeet het. Antwoorde van die vraelys is vergelyk met die werklike sout inname wat bepaal is vanaf ŉ enkel 24 uur uriene monster en ook met 24 uur bloed druk metings.

Resultate: Daar was geen betekenisvolle korrelasie tussen die sout inname gebaseer op die vraelys en 24 uur uriene monster in die blanke (r=0.07; p=0.40) en swart (r=-0.53; p=0.56) populasie, voor en na daar gekorrigeer was vir veranderlikes. Geskatte sout inname van die vraelys het betekenisvol gekorreleer met SBD in die blanke populasie (r=0.23, p=0.004), voor en na daar gekorrigeer was vir veranderlikes. Geen korrelasies (gekorrigeer of nie) was betekenisvol in die swart populasie nie (p>0.05). Die *Bland-Altman* grafieke vir sout inname het die gemiddelde verskil in sout inname gewys tussen die twee metodes vir die blanke populasie - 0.5 g/dag, en vir die swart populasie - 1.9 g/dag. Die sout ekskresie vanaf die uriene wys sout inname as 9.6g/dag hoër as die van die vraelys of 11.1g\dag laer as die van die vraelys in die blanke populasie, en in die swart populasie as 10.8g\dag hoër of 18.4g\dag laer as die vraelys. Die vlak van ooreenkoms (*Cohen's Kappa* analises) tussen die sout frekwensie vraelys en die 24 uur urien ekskresie was bepaal deur die populasie op te deel in twee kategorie naamlik, die groep wat wel die doelwit van <5 gram sout ŉ dag bereik en die wat nie. Die waarde van Kappa vir die blanke individue was 0.17 (geringe ooreenkoms) en vir die swart individue was die -0.06 (geen ooreenkoms). In die blanke populasie was daar ŉ betekenisvolle verhoging in SBD en

ook DBD soos wat die tertiele van sout inname verhoog het, volgens die vraelys (p<0.006 and p<0.02). In die swart populasie was daar geen betekenisvolle verskille in BD vlakke nie (p>0.05).

Die vyf voedsel soorte wat die meeste bygedra het tot albei die populasie groepe se sout inname was: diskresionêre sout, sous (vars gemaak of met poeier aangemaak), sop en biltong. Daar was geen verskille in die BD vlakke tussen die individue wat die vraelys beantwoord het, in terme van hulle kennis en gesindheid teenoor sout inname in albei etniese groepe (p>0.05). Daar was ook nie verskille in hulle 24 uur urien ekskresie nie (p>0.05). Net sekere gedrags faktore wat in die vraelys genoem word, het gereflekteer in die werklike sout inname en bloed druk.

Gevolgtrekking: Die kort sout frekwensie vraelys kan gebruik word om voedsel soorte te identifiseer wat bydra tot die totale sout inname. Die vraelys het egter die werklike sout inname onderskat. Die gebruik van hierdie vraelys kan behulpsaam wees in epidemiologiese studies om voedsel soorte te evalueer wat bydra tot totale sout inname en ook as monitering van die gemiddelde sout inname van ’n populasie om vas te stel wie die doelwit van minder as 5g\dag bereik.

Die kennis, gesindheid en gedrag van mans en vroue in albei etniese groepe was het nie gereflekteer op hulle werklike sout inname en BD nie, veral onder die swart populasie. Die meerderheid van die individue in albei populasies neem baie hoër inname van sout in as die voorgeskrewe minder as 5 g\dag.

Dus, publieke bewusmaking veldtogte om sout inname te verlaag na minder as 5g\dag deur die Departement van Gesondheid en die *Heart and Stroke Foundation* is lofwaardig.

Sleutelwoorde: Sout, Natrium, Urien natrium ekskresie, Kennis, Gesindheid, Gedrag, Sout frekwensie inname, Vraelys

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Conversion

The conversion of different units of salt for sodium and salt is as follows:

1 g of sodium = 2.5 g of salt

1 mmol of sodium = 23 mg of sodium

1 g of salt = 0.4 g of sodium

1 g of salt = 17 mmol of sodium

On a weight basis: salt comprises 40% sodium and 60% chloride (WHO, 2012).

List of abbreviations

AI - adequate intake level

BP - blood pressure

CCHS - Canadian Community Health Survey

CVD – cardiovascular disease

CFCT - condensed food composition tables

DASH - Dietary Approaches to Stop Hypertension

DBP - diastolic blood pressure

DoH - Department of health

DRI - Dietary Reference Intakes

ECF - extracellular fluid

ESC - European Society of Cardiology

ESH - European Society of Hypertension

FFQ - food frequency questionnaire

FoodBev SETA - Food and Beverages Manufacturing Sector Education and Training Authority

HT - hypertension

MRC - Medical Research Council

Na/K ATPase - sodium potassium adenosine triphosphatase pump

NHANES - National Health and Nutrition Examination Survey

PREDICT - Prospective study on the Early Detection and Identification of Cardiovascular disease and Hypertension

RAAS - renin-angiotensin-aldosterone-system

SAAWG – South African association of women graduates

SADHS - South African Demographic and Health Survey

SBP - systolic blood pressure

UJWSA – Union of Jewish women in South Africa

UL - upper level

WHO - World Health Organization

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Chapter 1: Introduction

1.1 General introduction

High blood pressure (BP) or hypertension (HT) is one of the worldwide leading risk factors for mortality and morbidity as a result of coronary artery disease, myocardial infarction, congestive heart failure, atherosclerosis and other vascular diseases (Lopez *et al.*, 2006).

In South Africa, HT is the most common widespread condition which contributes to serious complications such as stroke, ischaemic heart disease, and myocardial infarction (Norman *et al.,* 2007). South Africa's Demographic and Health Survey (SADHS) in 1998 described the national prevalence of HT using a cut-off point of 140/90 mmHg within the different ethnic groups (Steyn *et al.,* 2001). Hypertension were found in 25.2% of the adult population, which amounts to approximately 6 million South Africans. More recent statistics from South Africa revealed that 20% of deaths in the 35- to 64-year age group could be attributed to chronic lifestyle diseases, including HT (Statistics South Africa, 2005).

High BP can be the basis of severe disorders and cause of death or disability in a large number of our population. This highlights the importance of studying HT in the South African population as well as the relevance to modern research.

For consistency we used the term "sodium" unless term "salt" will be specified.

1.2 Dietary sodium intake

Dietary sodium is consumed in various ways such as naturally occurring sodium in food, or through processing and seasoning, including an amount of discretionary sodium (salt added during cooking and at the table). The current World Health Organization (WHO) and South African Department of Health (DoH) recommendations for adults are to reduce total salt intake from the levels of 9 to 12 grams per day (equal to 3600 to 4800 mg of sodium) to 5 grams per day (2000 mg of sodium) or less (DoH, 2011; WHO, 2012). The average daily consumption by South Africans remains high: 7.8 g among black persons, 8.5 g among mixed-race persons, and 9.5 g among white persons in South Africa (Charlton *et al.,* 2005).

Excess of sodium intake may play an important role in regulating BP (Sacks *et al.,* 2001; Polonia & Martins, 2009). Hypertension may develop in people with a sodium intake higher than 2400 mg per day (Sacks *et al.,* 2001). Several systematic reviews and meta-analyses of randomised control trials revealed a dependent relationship between sodium intake and BP: accumulation of sodium in the blood will result in fluid retention, which increases BP (Cutler *et al.,* 1997; He & MacGregor, 2002; Hooper *et al.,* 2002; He & MacGregor, 2003).

1.3 Methods to determine of dietary sodium intake

Several methods have been used to estimate dietary sodium intake including measuring urinary excretion of sodium and dietary survey methods (salt frequency questionnaire, food-frequency questionnaires) (Findiet Study Group, 1998; Bentley, 2006; Bernstein & Willett, 2010). The use of dietary methodology for an accurate estimation of total sodium intake may present a challenge due to various limitations. These could include an incompleteness of food composition databases or difficulty with accurately measuring discretionary salt because food composition databases do not consider the addition of salt at the table and during food preparation (Cummins *et al.,* 1983; Liu & Stamler, 1984; Subar *et al.,* 2001; Leiba *et al.,* 2005; Wolmarans *et al.,* 2010).

1.4 Twenty four hour urinary sodium excretion

The 24-hour urine collection method is considered to be the most objective approach for estimating sodium intake in epidemiologic studies (WHO/PAHO, 2010). In healthy individuals, renal excretion captures more than 90 % of the ingested sodium, including discretionary salt (Luft *et al.,* 1982; Clark & Mossholder, 1986). Therefore, the 24-hour urine collection is considered the 'gold standard' for the assessment of sodium intake (Bentley, 2006). An average level of dietary salt intake of the study population can be estimated by measuring 24-hour urinary sodium excretion in a representative sample of individuals. However, this method has several limitations: it is expensive; participant burden is high, may lead to high rates of incomplete collection and is difficult to use if the large studies (Bentley, 2006).

1.5 Salt behaviour questionnaire

The WHO Expert Group for cardiovascular disease prevention through population dietary salt reduction developed the salt behaviour questionnaire (WHO/PAHO, 2010). For the purpose of the present study, the questionnaire focuses on discretionary salt intake and includes questions about salt added during cooking and at the table.

1.6 Salt intake frequency questionnaire

A short food-frequency type questionnaire was developed from a multi-ethnic, economically active sample of the South African population (Charlton *et al.,* 2007) to assess total dietary sodium intake. The main limitation of the questionnaire is that the tool does not include sodium consumption based on an estimated quantity of food: the more food a person consumes, the more likely it is that their intake of sodium will be higher (Charlton *et al.,* 2007).

1.7 Rationale for the study

One of the possible contributors to the high prevalence of HT in South Africa may be an excessive sodium intake (Selassie *et al.,* 2011). Several studies have observed BP lowering effects associated with the introduction of a low sodium diet (Law *et al.,* 1991; Sacks *et al.*, 2001; Charlton *et al.,* 2005; Appel *et al.,* 2006; Aparna, 2009).

The most accurate method to estimate sodium intake is by 24-hour urine collection, but this method is expensive and also impractical in large field studies. Questionnaires relating to the behaviour and frequency of salt intake are less challenging to administrate.

This study aims to find a reliable method to replace 24-hour urine collections in assessing dietary sodium intake. Results from this study will help to assess the validity of the salt frequency and behaviour questionnaires which may be used in the national surveys to estimate habitual dietary salt intake in South Africans.

1.8 Aim and objectives

The aim of the present study is to determine the agreement and relationship between habitual dietary intake of sodium, using two different questionnaires and 24-hour urine sodium excretion and BP for a young adult normotensive population residing within the Potchefstroom area of the North West province of South Africa.

Study objectives:

1) To calculate dietary sodium intake using:

a) 24-hour urinary excretion; and

b) a salt frequency questionnaire;

2) To determine the agreement between the salt frequency intake questionnaire and the 24-hour urinary sodium excretion;

3) To describe the salt behaviour patterns of the study population using a salt behaviour questionnaire;

4) To determine the relationship between salt behaviour and 24-hour urine Na excretion; and

5) To determine and compare the relationship between BP and

a) urinary sodium excretion;

b) the salt frequency questionnaire; and

c) the salt behaviour questionnaire.

1.9 Hypothesis

1) There is a significant positive correlation between salt frequency intake and the 24-hour urine sodium excretion;

2) There is a significant positive correlation between salt behaviours and 24-hour urine sodium excretion;

3) A direct relation exists between BP and:

a) urinary sodium excretion;

b) salt frequency intake;

c) salt behaviour.

4) There is a reliable salt behaviour questionnaire with validity available to estimate habitual dietary salt intake among South Africans.

1.10 Significance of the study

The South African government published regulations for the gradual reduction of salt content of foodstuffs over a period of six years in eleven different food categories in March 2013 (Government Gazette, RSA, 2013). In the light of this, results of the present study will provide new scientific information which could be used to monitor salt intake of the population. It also will provide baseline information on the current dietary salt intake of the South African population. This is one of the important aspects of this study.

Thus, a short term outcome of this study (immediately upon completion) will yield results to assess the validity of the salt behaviour and salt frequency questionnaires which may be used in the national survey to estimate habitual dietary salt intake among South Africans.

As a long term outcome (after 2-3 years), the further assessment of available information could be translated into practical guidance which may be used in the development of a national strategy for South Africans to reduce levels of salt intake and will encourage people to make healthy food choices and lifestyles. Indeed, implementation of such a strategy might represent a highly cost-effective way of reducing the growing burden of HT in South Africa.

1.11 Structure of the thesis

This thesis is presented in the article format. The compilation of chapters is written according to the requirements of the North-West University (Chapters 1, 2, 5 and 6) and of the journal to which the article manuscripts included will be submitted (Chapters 3 and 4). Directives in terms of formatting and quoting sources were strictly followed.

The content of each chapter is briefly described below.

The introductory chapter (Chapter 1) provides a general introduction to the research problem addressed in this dissertation. It also presents the objectives and hypothesis, and describes the significance of the study.

Chapter 2 includes a detailed review of the HT problem in South Africa and in the world, describing the important role of dietary sodium for the human body in regulating blood pressure levels and describes different methods to estimate sodium consumption by populations.

Chapter 3 includes an article where the dietary sodium (salt) intake was estimated from the short salt frequency intake questionnaire and compared to the 24-hour urinary salt excretion and blood pressure in young normotensive healthy white and black South Africans. The article will be submitted to an appropriate peer review journal.

Chapter 4 includes an article where comparison of dietary sodium (salt) intake (measured by 24-hour sodium excretion) and blood pressure profiles of normotensive white and black participants was done according to their knowledge, attitude and behaviour to sodium (salt). The article will be submitted to an appropriate peer review journal.

Chapter 5 gives a summary of the main findings of this dissertation and recommendations.

For chapters 1, 2 and 5 a collective reference list is included in chapter 6. Article manuscripts have their own reference lists provided at the end of specific chapter.

Annexure A: The short salt frequency intake questionnaire

Annexure B: The knowledge, attitude and behaviour questionnaire

Chapter 2: Literature review

2.1 Introduction

Sodium, an essential nutrient, is tightly regulated by the human body. However, when consumed in excessive amounts it has adverse cardiovascular and non-cardiovascular health effects (Meneton *et al*., 2005).

The current WHO recommendation for adults is to reduce salt intake from the current levels of 9 to12 grams per day (equal to 3600 to 4800 mg of sodium) to less than 5 grams per day (2000 mg of sodium) (WHO, 2012). The average salt intake in most countries around the world is approximately 9 to 12 grams per day (Brown *et al*., 2009). Although the South African Department of Health also recommends a maximum salt intake of 5 grams per day, the average daily consumption remains high: 7.8 grams among black persons, 8.5 grams among mixed-race persons, and 9.5 grams among white persons in South Africa (Charlton *et al.,* 2005; Seedat *et al*., 2006).

Thus, South Africans consume more than the recommended sodium intake level daily, which is mostly due to the excessive quantities of salt added to food including processed and packaged foods (Charlton *et al.,* 2005; Wentzel-Viljoen *et al*., 2013).

2.2 Regulation of sodium on the body

The sodium ion is essential for metabolic processes in the cell. Sodium is involved in the maintenance of plasma volume, acid-base balance, and transmission of nerve impulses (Holbrook *et al*., 1984; Taal *et al*., 2011). Sodium participates in the transport of molecules across cell membranes and in the maintenance of electrochemical gradients via the sodium potassium adenosine triphosphatase pump (Na/K ATPase) (Guyton & Hall, 2006). The osmotic properties of sodium determine the extracellular fluid (ECF) volume, including plasma and interstitial volumes (Meneton *et al*., 2005). Therefore, the total body sodium content determines the blood volume and thus the BP. Regulation of sodium balance occurs by means of complex interactions between neuro-hormonal and renal mechanisms, which maintain the ECF volume and arterial BP (Burnier, 2008; Guyton & Hall, 2006). Maintenance of the sodium balance by the neuro-hormonal feedback mechanism includes the renin-angiotensin-aldosterone-system (RAAS) and the sympathetic nervous system (Luft *et al*., 1979; Friberg *et al*., 1990). Hypothalamic sympathetic inhibition may be responsible for the rise in arterial pressure when the cerebrospinal fluid (CSF) sodium concentration rises as the result of the direct effect of plasma sodium on the neuronal activity. Increase in sodium concentration diminishes synaptic transmission and neuronal excitability, and a small rise in

the sodium concentration in the anterior hypothalamus reduces the local release of norepinephrine. Regulation facilitated by the renal mechanism alters sodium excretion rates to match sodium consumption; therefore, for the short terms, human bodies can tolerate different levels of sodium intake. For example, the multi-national Intersalt study found sodium consumption to be 21 mg per day among the Brazilian Yanomamo tribe, and individuals in China on average consumed 5650 mg per day (Intersalt, 1988).

Figure 2.1 illustrates how intake of dietary salt influences the BP via an increase in ECF volume (De Wardener *et al*., 2004). Steps are shown by which salt intake influences plasma sodium concentration and extracellular fluid volume and affects BP. The sequential steps by which salt intake influences arterial BP shown. They include an effect on plasma sodium concentration and extracellular fluid volume. The greater rise in plasma sodium, which occurs in hypertensive subjects, is due to a defect in the kidney's ability to excrete salt and to regulate extracellular fluid volume.

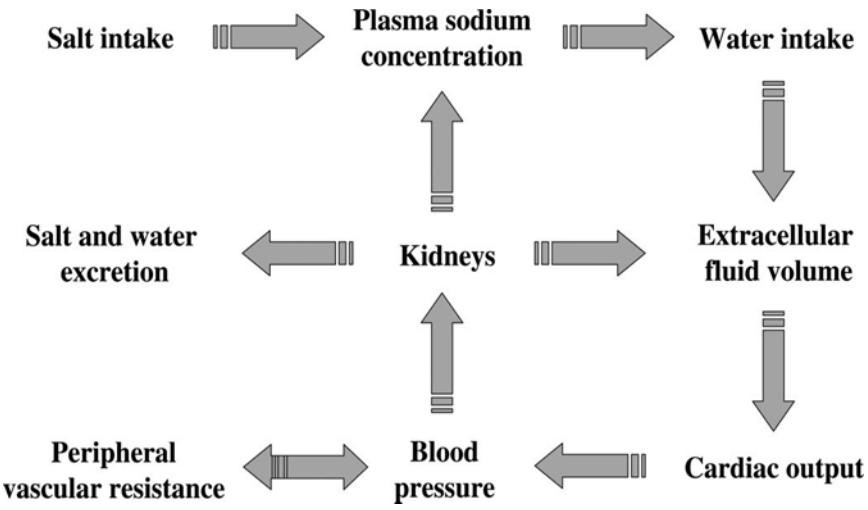

Figure 2.1: Links between dietary salt intake and BP (De Wardener *et al*., 2004).

2.3 Dietary sodium intake worldwide and in South Africa

Sodium plays a principal role in the composition, sensory properties and preservation of food (Hutton, 2002). One of the primary roles of sodium is to improve taste and flavour as well as enhance other flavours of foods (Gillette, 1985). Despite modern advances in food packaging and storage, sodium still plays a central role in food preservation and food safety (Institute of Medicine, 2010; Mhurchi *et al*., 2010). Thus, a great deal of the sodium is already presents in foods that have been processed. Sources of salt in the diet differ among countries. In developing countries such as South Africa, a large proportion of total salt intake is discretionary salt (salt added during cooking or at the table) (Brown *et al*., 2009). Charlton *et al*. (2005) determined that the discretionary salt intake for South Africans are

between 33% and 46% for three different ethnic groups. Contrary, in developed countries it is a much lower since 75% to 85% of total salt intake comes from processed foods (Mattes & Donnelly, 1991).

Two recent evaluations of the food supply in Australia (Webster *et al*., 2010) and the United Kingdom (Mhurchi *et al*., 2010) found the highest amounts of sodium (mg per 100g) in sauces and spreads, including tomato sauce, processed meat, smoked and canned fish, pickled vegetables, and snack foods. An analysis of the Canadian Community Health Survey (CCHS) examined the relative contribution of food group categories to sodium intake (Mhurchi *et al*., 2010). Among all of the participants, bread contributed the most sodium to the diet (14% of sodium contribution) because it is consumed in large quantities. Other foods contributing large amounts of sodium included processed meats (9% contribution), pasta dishes (6%), cheese (5%), and canned, pickled vegetables (5%) (Mhurchi *et al*., 2010). In the United States, foods contributing the most sodium to the diets of the 2005-06 National Health and Nutrition Examination Survey (NHANES) participants were breads (7.3%), processed chicken meat (6.9%), pizza (6.8%), pasta and pasta dishes (6.3%), cold meat (5.1%), and seasonings (4.4%) (National Cancer Institute, 2010).

As mentioned earlier, South Africans consume excessive amounts of sodium compared to the recommended intake levels. Results of recently conducted surveys in three provinces indicated that the average salt intake varied from 6 to 11 grams per day per person (Charlton *et al*., 2005; Lategan, 2011; Norton & Woodiwiss, 2011). Analyses from the studies conducted in South Africa in different cultural groups indicates that bread contributed the most sodium to the diet (up to 40% of the sodium intake), depending on the ethnic group. Other foods with large amounts of added sodium included margarine (13%) in some groups, soups and gravy powders (17%) in some populations, and atchar (5%) in the Indian population (Wentzel-Viljoen *et al*., 2013).

2.4 Adverse effects of excess dietary sodium

There is strong evidence that salt added to food is a major factor in increasing the BP in normotensive and hypertensive people (He & MacGregor, 2006; Mohan *et al*., 2006; He & MacGregor, 2009). High BP resulting from excess sodium intake is considered to be the primary mediator of adverse cardiovascular events (Dickinson & Havas, 2007). Habitual sodium intake that exceeds 2000 mg per day is considered to increase the risk of developing HT (Institute of Medicine, 2005).

In a recent meta-analysis of 19 observational studies, a high sodium diet was positively associated with a risk of total CVD (Strazzullo *et al*., 2009). Furthermore, data from the NHANES Epidemiologic Follow-up Study suggests that high sodium intake (>2400 mg per

day) increases the risk of heart failure and has also been associated with impaired vascular function (Dickinson & Havas, 2007; Jablonski *et al*., 2009). There is evidence that excess dietary sodium contributes to non-cardiovascular conditions such as kidney stones, asthma and incidence of gastric cancer (Joossens *et al*., 1996; de Wardener *et al*., 2004). In summary, during the past decade there is increasing evidence that high levels of salt consumption lead to the risk of various health disorders.

2.5 Hypertension and its management

2.5.1 Hypertension and its classification

Hypertension is a chronic systemic disease characterised by an abnormally high BP. Blood pressure is classified based on the combined systolic and diastolic pressures of the vascular system. Systolic BP refers to the pressure in arterial vessels during a heartbeat. Diastolic BP refers the pressure in the arterial vessels between heartbeats. The optimal BP in the cardiovascular system is reflected by a systolic BP value of 120 mmHg and diastolic BP value of 80 mmHg (120/80 mmHg) (Guyton & Hall, 2006). A person is regarded as hypertensive if their BP reading is higher than 140/90mmHg (Mancia *et al*., 2013). Classification of HT according to the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) Guidelines is shown in Table 2.1 (Mancia *et al*., 2013).

Table 2.1: Definitions and classification of BP levels (mmHg)

Category of BP	SBP		DBP
Optimal	<120	and	<80
Normal	120–129	and/or	80–84
High normal	130–139	and/or	85–89
Stage 1 HT	140–159	and/or	90–99
Stage 2 HT	160–179	and/or	100–109
Stage 3 HT	>180	and/or	>110

SBP - systolic BP; DBP – diastolic BP (Mancia *et al*., 2013)

Abnormally high BP is generally divided into two main categories: essential HT and secondary HT. Essential or primary HT has an unknown origin and accounts for 90% to 95% of all HT cases (Guyton & Hall, 2006:232). As a result of elevated BP beyond the norm, the heart is forced to work harder to overcome the increased systemic pressure in order to

deliver blood to tissues. A strain on the heart may contribute to the potentially deadly conditions such as congestive heart failure, myocardial infarction and kidney failure (Pierdomenico *et al*., 2009). Usually HT does not present with signs or symptoms and accordingly it is often referred to as the silent disease. The only possible symptoms that may occur are headaches localised in the occipital region, drowsiness, vision impairment and nausea (Mbokazi, 2006).

Several risk factors may contribute to the occurrence of essential HT. These include age, gender (WHO, 2003), level of urbanisation, obesity and sedentary lifestyle (Mbokazi, 2006) and certain dietary factors (Appel *et al*., 1997).

A strong correlation exists between high-fat intake, obesity and hypertension. High dietary fat intake can lead to obesity which is one of the risk factors for primary HT (Mayers & Gokce, 2007). An increase in body weight leads to an increase in blood volume. Thus, the pressure that the blood exerts on the walls of blood vessels increases (Guyton & Hall, 2006:407). In addition, a high dietary fat intake and excess adiposity is associated with elevated inflammatory markers and oxidative stress (Pou *et al*., 2007). These markers, in turn, may contribute to endothelial dysfunction (Vincent *et al*., 2007).

The first SADHS found the prevalence of obesity among the population of South Africa to be more than 29% in men and 56% in women. Among black people 30% of the women and 8% of the men were considered to be obese (Medical Research Council, 1998; Puoane *et al*., 2002). Obesity, especially abdominal obesity is associated with higher BP. In obese people who have a body mass index (BMI) ≥ 30 kg/m^2, the risk for HT is five times higher than normal BMI <25 kg/m^2 (Cooper *et al*., 1997; Kruger *et al*., 2001). Although, a more recent study suggests that obesity is not the main driving force behind the high blood pressure (Schutte *et al*., 2008). Thus, in the light of above mentioned studies the consequences of obesity should be understood better and it may enhance motivation to prevent excessive body weight gain.

2.5.2 Hypertension in South Africa

One in four South African adults has essential HT with a higher prevalence among the black population (Mbokazi, 2006; Thorogood *et al*., 2007). About 6.5 million black South Africans have a high BP above 140/95 mm Hg and 3.2 million above 160/95 mm Hg (Milne & Pinkney-Atkinson, 2004). Studies conducted in 1983-84 among adult Zulu people in the Durban area of KwaZulu-Natal indicated that 25% of the urbanised Zulus suffered from HT compared to 9% of their rural counterparts. These findings indicated that HT had become a

greater problem with the urbanisation of black South Africans (Seedat, 1983; Seedat & Hackland, 1984). These findings correspond with the results of other studies that admited that black people are especially prone to the development of HT and have a 35% greater risk of progressing from the pre-HT stage to HT than whites (Mbokazi, 2006; Appel, 2009; Selassie *et al*., 2011). Indeed, black hypertensive patients in South Africa have been reported to display many risk factors associated with the development of a stroke and chronic kidney disease, leading to congestive heart failure (Seedat, 1999). Indeed, in a later study conducted by Seedat (2006), the evidence indicated that the incidence of coronary heart disease is increasing rapidly among this population group (Seedat, 2006). The black population of South Africa is in transition and going through lifestyle changes (including dietary changes) which they need to process. In conclusion, HT is an important public health problem in South Africa.

2.5.3 Non-pharmacologic therapies for HT

Lifestyle modifications such as dietary changes may be useful for the prevention or treatment of HT. Dietary sodium restriction (especially from table salt) is considered an effective non-pharmacologic therapeutic option to treat elevated BP levels (Appel, 2009; Danaei *et al*., 2009; Pimenta *et al*., 2009; Rayner, 2010; Selassie *et al*., 2011). Lowering sodium intake (especially from table salt) reduces excessive water retention, which helps to maintain normal BP (Apple *et al*., 1997).

Additional dietary changes that are beneficial to reducing BP include adopting a diet similar to Dietary Approaches to Stop Hypertension (DASH-style diet) rich in fruits, vegetables and low-fat dairy foods that are low in dietary sodium as well as saturated and total fat (Appel *et al*., 1997; Sacks *et al*., 2001; Chobanian *et al*., 2003; Champagne, 2006). Several studies have observed BP lowering effects associated with the consumption of a DASH-style diet combined with a low sodium diet or similar diets (Sacks *et al*., 2001; Charlton *et al*., 2005; Appel *et al*., 2006; Aparna, 2009).

Thus, dietary modification is an important lifestyle change that can help prevent the development of hypertension. Sodium restriction combined with a DASH-style diet is currently the primary dietary therapy for HT (Sacks and Campos, 2010).

2.6 Dietary sodium and hypertension

2.6.1 Recommended sodium intake

The Dietary Reference Intakes (DRI) developed by the Institute of Medicine of United States

contains recommended intake levels of sodium which may reduce the risk of sodium excess (Murphy & Poos, 2002). The DRI values for sodium include an adequate intake level (AI) and upper level (UL), which are reported in Table 2.2. The AI was established in order to replace insensible sodium losses (i.e., in sweat) and to ensure adequate consumption of other nutrients. The UL for sodium was established to reduce the risk of developing HT and related cardiovascular and other health conditions in the general population (Institute of Medicine, 2005). The South African Non-Communicable Disease Summit in September 2011 set the targets to reduce the intake of salt to <5 grams per day by 2020.

Table 2.2 Dietary Reference Intake levels for sodium by age category*

Age Category	Adequate Intake Level (mg/day)	Tolerable Upper Level (mg/day)
1 to 3 years	1000 mg	1500 mg
4 to 8 years	1200 mg	1900 mg
9 to 13 years	1500 mg	2200 mg
14-50 years	1500 mg	2300 mg
51 to 70 years	1300 mg	2300 mg
Over 70 years	1200 mg	2300 mg

*Institute of Medicine, (2005)

2.6.2 Dietary sodium and clinical outcomes in hypertension

Although sodium plays an important role in regulating BP accumulation of sodium in the blood will result in fluid retention, which increases BP. One of the first randomised controlled trials (Sacks *et al*., 2001), was conducted with 412 participants with BP levels higher than 120/80mmHg (SBP and DBP respectively). Participants consumed a usual diet with a reduction in sodium from 3300 mg per day to the 2400 mg per day. Results showed a significant reduction of SBP by 2.1 mmHg ($p<0.001$) and DBP by 1.3 mmHg ($p=0.03$), A further reduction of sodium to the 1500 mg per day resulted in an additional decrease of SBP by 4.6 mm Hg ($p<0.001$) and DBP by 1.7 mm Hg ($p<0.01$) (Sacks *et al*., 2001). Thus, the conclusion was that for patients with pre-HT and HT reducing dietary sodium intake to a level of 1500 mg per day may reduce the BP by about the same level as single drug therapy.

For the past few decades, a large number of randomised controlled trials have been analysed in order to establish the effect of reducing salt intake on BP. Several meta-analyses have been published and reveal a correlated response between sodium intake and

BP: BP increased with the higher dose of sodium intake (He & MacGregor, 2002; Hooper *et al*., 2002; He & MacGregor, 2003; Taylor, *et al*., 2011). Most of the trials underlined the significant effect of short-term salt reduction. The range of sodium reductions from 2300 mg to 1600 mg per day (equal to 5.9 and 4.0 to grams of salt) significantly reduces SBP/DBP in hypertensive and in normotensive people.

The following examples will be used to review the results. A meta-analysis of sodium restriction trials of more than 4 weeks duration found that sodium reduction to 1860 mg per day lowered mean SBP by 2.0 mmHg ($p<0.05$) and DBP by 1.0 mmHg ($p<0.05$) in non-hypertensive and SBP by 5.0 mmHg ($p<0.05$) and DBP by 2.7 mmHg ($p<0.05$) in hypertensive adults (He & MacGregor, 2002).

Results were confirmed by other research groups which assessed 188 subjects at different levels of dietary sodium intake: high (3000 mg per day), medium (2000 mg per day) and low (1200 mg per day) for 30 days (Obarzanek *et al*., 2003). The study reported that lowering dietary sodium intake was associated with a significant ($p=0.002$) lowering of BP in all the tested subjects.

The results of the He and MacGregor (2003) study also showed that a reduction of sodium intake from 4800 mg to 3600 mg per day and then to 2400 mg (12 grams, 9 grams and 6 grams of salt respectively) was associated with a significant reduction in BP (study duration from four to six weeks). They reported a decrease in SBP ranging from 3.6 to 5.6 mmHg and that of DBP from 1.9 to 3.2 mmHg in hypertensive people and the range decrease in SBP from 1.8 to 3.5 mmHg and the DBP from 0.8 to1.8 mmHg in non-hypertensive subjects (all $p<0.05$ for both SBP and DBP).

The Cochrane database systematic review findings are estimate that consistent salt reduction is beneficial to reductions in systolic BP between 1 and 4mmHg in both normotensive and hypertensive people (Taylor *et al*., 2011). One of the latest meta-analyses conducted on 37 controlled trials in a study carried out by Aburto *et al*. (2013), showed a significant reduction in the SBP an average by 3.39 mmHg and the diastolic BP by 1.54 mmHg when the sodium intake was reduced to 2000 mg per day.

Thus, in conclusion, all the above mentioned findings support the definite benefit of dietary salt reduction for BP levels. However, further studies need to be carried out in order to assess the level of salt intake in South African population in order to find effective ways to reduce the salt intake and which would be practical and inexpensive.

2.7 General methods of sodium assessment

2.7.1 Twenty-four hour urine collection

Twenty-four hour urinary excretion of sodium is the current gold standard for the estimation of sodium intake (WHO/PAHO, 2010). Urinary excretion of sodium over a 24-hour period is used to test daily sodium consumption. In healthy individuals, renal excretion captures more than 90% of the ingested sodium, including discretionary salt (Clark & Mossholder, 1986; Espeland *et al*., 2001). Acute, moderate variations in sodium intake are also reflected in the urine. For 10 days, Luft *et al*. (1982) gave certain amounts of sodium (between 1150 and 5750 mg per day) to healthy individuals and observed a good relationship between the amount of sodium ingested and excreted ($p<0.05$).

There are several strengths and limitations regarding the 24-hour urine collection method. The benefit of this method is that it provides an objective measure of ingested sodium. In contrast to food reporting methods, this method is free of reporting bias. Indeed, it is not associated with analytical errors compared to those found in food composition databases (McCullough *et al*., 1999). The 24-hour urine collection is also ideal because it captures sodium excretion over a 24-hour period and does not depend on variations in the times of sodium consumption and sodium excretion. Nonetheless, there are some limitations. Part of the problem is large personal every day variability in sodium consumption. This makes it necessary to obtained from 7 to 10 days to determine an individual's sodium intake (lui & Stamler, 1984). The other limitation it is expensive and participant burden is high, which may therefore lead to high rates of incomplete collection, thus rendering it a difficult collection method in field studies (Bentley, 2006). Also subjects may not adhere to the collection protocol, may not collect each void, which would lead to unusable or inaccurate samples.

2.7.2 Other urinary methods

The use of spot urine collections has been explored as an alternative objective estimate of sodium intake, which would reduce subject burden. Spot urine collections have been investigated as an alternative to 24-hour urine collections for estimating sodium intake (Mann & Gerber, 2010). This method requires the collection of one void only. The spot urine collection could be a random urine sample, or the second void of the day, or the collection of one void in the afternoon, or early morning. There is a lack of agreement which void is optimal. Comparison of spot urine collections with a 24-hour urine collection suggests that for the estimation of daily sodium intake an early evening spot collection is better ($p<0.001$) than a random collection ($p<0.33$) or a morning collection ($p=0.06$) (Mann & Gerber, 2010).

Spot urine collections have several limitations. For example, this method does not take into account possible variations in sodium excretion during the day. Thus, based on the complexities of using urinary excretion methods, the food reporting techniques are often used. These are includes food records, food recalls, and food frequency questionnaires.

2.7.3 Food intake methods

Food records constitute the non-biologic methods for assessing sodium intake based on their detailed nature of food intake. Subjects measure the amount of food and beverages prior to consumption and record any leftovers using a scale or household measures (i.e., measuring cups and spoons). However, food records tend to underestimate sodium intake. In a small group of healthy individuals, Schachter *et al*. (1980) found that food records underestimated sodium intake by approximately 350 mg, when compared to duplicate food portions. Nonetheless, certain studies found a significant linear relationship between food records and 24-hour urinary excretion (Clark & Mossholder, 1986). Therefore, generally, food records provide a reliable estimate of sodium intake in healthy populations but may be challenging in certain subgroups of individuals. Some of them are under-reporting of undesirable food items and can be burden for both the participant and the investigative team (Sawaya *et al*., 1996; Gibson, 2005). Food records also require extensive analysis by trained coders and errors may also occur.

The 24-hour food recall is another common method used to assess sodium intake. Because it is highly feasible, it is the dietary assessment technique chosen for large epidemiologic studies from which the population sodium intake estimates were derived (Fischer *et al*., 2009). Subjects are required to recite all food and beverages consumed in the 24 hours preceding the interview date. This method is relatively inexpensive, easily administered, and the respondent burden is light. However, the 24-hour recall technique is retrospective and the sodium intake tends to be underestimated when compared with sodium obtained from 24-hour urinary excretion (Day *et al*., 2001; Espeland *et al*., 2001).

The food frequency questionnaire (FFQ) is a semi-quantitative dietary assessment tool often used in large epidemiologic studies to measure habitual food intake and changes in food intake over time. The sodium intake reported in FFQs may be underestimated compared to urine collections (Day *et al*., 2001). The calculation of dietary sodium intake by Condensed food composition tables (CFCT) for South Africa is not likely to be accurate compared to actual intake. Studies validating an FFQ against one or two 24-hour urine collections and/or food recalls find poor agreement relating to sodium intake and excretion respectively (Subar *et al*., 2001). The estimated sodium intake in FFQ has notable limitations. There is no salt

added to the foods listed in the CFCT, no information on the salt content in the fast foods, and culture-specific recipes (Wolmarans *et al*., 2010).

2.7.4 Salt behaviour questionnaire

The WHO/PAHO Expert Group for Cardiovascular Disease Prevention through Population Dietary Salt Reduction developed the salt behaviour questionnaire (WHO/PAHO, 2010). The questionnaire focuses on discretionary salt intake and includes the questions about salt added during cooking and salt added at the table. The questionnaire analysis estimates the participant's behaviour and attitude with regard to salt usage, possible health problems linked to salt intake and whether the participant does something to control salt intake. The salt behaviour questionnaire is completed during individual interviews conducted by the researchers (WHO/PAHO, 2010).

2.7.5 Salt intake frequency questionnaire

For the purpose of this study, the questions about frequency intake of salt were adapted from the study of Charlton *et al.* (2007). A short, food-frequency type questionnaire was developed from a multi-ethnic, economically active sample of the SA population in order to assess the total habitual sodium intake. This questionnaire is simple, requires little participant time and effort, and can assess habitual sodium intake (including discretionary sodium) of the study population. The questionnaire contained 42 items, mostly industrialised foods such as canned foods, dairy and meat products, condiments, snacks and fast food. Participants were asked how frequently each food was consumed during the last 7 days, with responses ranging from 0 (never) to 5 (3+ per day). For each food on the list, portion size was compared with the average for that food, and was adjusted to the nearest standard portion size in the Food finder dietary assessment computer program, based on the Medical Research Council (MRC) food quantities manual (Langenhoven *et al*., 1991).

Authors also attempted to account for discretionary salt intake by considering responses from a set of qualitative questions about the use of salt and flavour enhancers in food preparation, whether salt was usually added to food before tasting it, and about the preference for a salty taste in foods. If salt was used in food preparation, an additional salt amount was added to the composite sodium content of the questionnaire. The main limitation of the questionnaire is that the tool does not include sodium consumption based on the estimated quantity of food: the more food a person consumes, the more likely their intake of sodium will be higher (Charlton *et al.,* 2007).

2.8 Conclusion

In the literature review the following were discussed: the growing burden of hypertension in SA and around the world, an important role that sodium plays in regulating BP, several general methods of dietary sodium assessment including 24-hour urinary assessment, food intake methods and short salt knowledge, attitude and behaviour and salt intake frequency questionnaire.

Chapter 3: Article 1

3.1 The validity of a short salt frequency questionnaire to assess salt intake and identify foods contributing to salt intake

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Abstract

Objective: We validated salt intake estimated from a short salt frequency intake questionnaire (questionnaire) against 24-hour urinary salt excretion and blood pressure in young normotensive healthy white and black South Africans. In addition we assessed the contribution of different foods/food groups to total salt intake based on the questionnaire.

Methods: A questionnaire describing and quantifying salt intake of an individual, a single 24-hour urine sample and 24-hour blood pressures were obtained from 280 normotensive participants.

Results: There was a significant difference in salt intake based on the questionnaire between the white and black groups (p=0.01) but not for the 24-h urinary salt excretion. There was no significant correlation between the salt intake based on the questionnaire and 24-h urinary excretion in the white (r=0.07; p=0.40) and black (r=-0.53; p=0.56) participants before and after adjustment for covariates. Estimated salt intake from the questionnaire significantly correlated with SBP in white participants (r=0.23, p=0.004) before adjustment for covariates and was no longer significant after adjustment. None of the correlation (unadjusted or adjusted) were significant for the black participants (all p>0.05).

The Bland-Altman plots for salt intake showed the mean difference in salt intake between the methods for white group is 0.5 g/day, and for black is -1.9 g/day. The urinary salt excretion may estimate salt intake to be 9.6 g/day above or 11.1 g/day below the questionnaire's estimation in the white, and 10.8 g/day above and 18.4 g/day below in the black groups.

The level of agreement (Cohen's Kappa analyses) between the salt frequency questionnaire and the 24-hour urinary salt excretion were determined by categorising the participants in groups who meet the target of <5 grams salt per day or do not. The value of Kappa for the

white participants was 0.17 (slight agreement) and for the black participant it was -0.06 (no agreement).

There were a significant increase in both SBP and DBP of the white participants with the increasing of salt intake according to the tertiles of the questionnaire (p<0.006 and p<0.02 respectively). In the black participants there were no significant difference in BP levels (all p>0.05).

The five foods/food groups that contributed most in both ethnic groups were discretionary salt, bread, gravy made with stock or gravy powder, soup and biltong.

Conclusion: The questionnaire considerably underestimates the dietary salt intake of individuals in the studied population compared to the 24-h urinary excretion. However, the application of this questionnaire may be helpful in epidemiological studies evaluating the foods contributing to the total salt intake, monitoring average salt intake and assessing the proportion of the population not meeting the target of less than 5 gram salt intake per day. Our findings once again confirm the high salt intakes of young individuals highlighting the importance of population-based strategies to lower consumption.

Keywords: Salt, Sodium, Urinary sodium excretion, salt frequency intake questionnaire.

Introduction

Excessive dietary salt consumption is an important public health issue in South Africa and internationally. There is strong evidence that a high intake of salt is a major factor in the high prevalence of hypertension and cardiovascular disease (CVD) in the world[1-3]. The South African Department of Health (DoH) and the World Health Organisation (WHO)[4,5] recommend a salt intake of less than 5 grams a day (equal to 2000 milligrams of sodium). Currently South Africans consume between 6 and 11 grams salt per day (equal to 2400-4400 milligrams of sodium)[6-8].

Accurate measuring of salt intake is challenging. Typical dietary intake methodology is not reliable due to various reasons. Currently the 'gold standard' to assess salt intake is to measure salt in 24-hour (24-h) period urine excretion[9]. However, due to participants burden it may lead to high rates of incomplete collection, making it difficult in large studies and leading to inaccurate samples[10].

Short questionnaires are frequently developed to assess intake of a specific nutrient, for example fatty acids, iron and calcium[11-14]. Reliable estimations of habitual dietary salt intake are required to complete recommendations to reduce excessive consumption. Charlton and co-workers[15] developed a short questionnaire, based on the dietary intake of a multi-ethnic, economically active adult sample of the South African population[15]. However, the questionnaire considerably underestimated the salt intake in their studied population. The authors suggested that further validation studies of the questionnaire should be undertaken in other communities of South Africa with different eating patterns regarding processed foods and discretionary salt intake.

As part of a comprehensive strategy to reduce the salt intake of a population it is important to know the sources of the salt since it differs depending on the eating habits of the population. In developing countries such as South Africa, discretionary salt (salt added during cooking or at the table) contributes meaningful to the total salt intake[16]. Charlton *et al*.[6] determined that the discretionary salt intake for South Africans range from 33% to 46% for three different ethnic groups. Contrary, in developed countries discretionary salt usage is much lower with 75% to 85% of total dietary salt coming from processed foods[17].

Thus, our focus was to validate salt intake estimated from a short salt frequency intake questionnaire (questionnaire) against 24-hour urinary salt excretion and blood pressure in young normotensive healthy white and black South Africans. In addition we assessed the contribution of different foods/food groups to total salt intake based on the questionnaire.

For consistency throughout the article we used the term “salt” instead of “sodium”, unless otherwise specified.

Study population and methods

The present study has a cross-sectional design and is nested in the baseline phase of the African Prospective study on the Early Detection and Identification of Cardiovascular disease and Hypertension in South Africa (African-PREDICT). The study assesses and compares young, normotensive and apparently healthy white and black South Africans in terms of their cardiovascular, biological and psychosocial profiles.

Participant selection and recruitment

Recruitment was done by field workers, by means of invitations and advertisements. Potential participants signed an informed consent form before commencing with data collection. Participants with hypertension, infected with HIV, using medication for chronic diseases or had chronic diseases currently or previously, for example, cancer or diabetes, were excluded from the study. Depending on the screening results, those who complied with the inclusion criteria were invited to participate in a research project with a more detailed assessment of their health.

Data collection

The study was carried out at the clinic of the Hypertension in Africa Research Team (HART), North-West University. Data collection included a physical examination and blood pressure measurements of the participants who were individually interviewed in terms of a short salt frequency questionnaire, followed by a single 24-h urine collection. The first set of these data was performed at the time of the clinic visit with the urine collection scheduled to be completed within the next few days.

The physical examination comprised the measurement of body weight using calibrated SECA portable electronic scales (Germany) and height using a calibrated portable stadiometer SECA 213 model (Germany) to the nearest 0.1 kg and 0.1 cm respectively. Body mass index (weight (kg)/height (m^2)) was then calculated. Blood pressure (BP) was measured using the CardioXplore 24-h ambulatory BP monitor (Meditech, Hungary), according to the South African Hypertension Guidelines 2011[18]. Both systolic BP (SBP) and diastolic BP (DBP) were recorded.

All the participants who provided valid urine samples completed the short salt intake frequency questionnaire on the same day that the 24-h urine collections were returned. For

the purpose of this study, the short questionnaire developed by Charlton and co-workers[15] was employed. The questionnaire is simple, requires little participant time and effort and is easy to use. The questionnaire contains 42 food/food groups of mostly processed foods such as different types of bread, canned foods, dairy and meat products, condiments, snacks and fast food as well as discretionary salt. Participants were asked how frequently each food/food group was consumed during the previous 7 days, with responses ranging from 0 (never) to 5 (3+ times per day). The data was captured in Excel and exported to the SPSS™ v.22 programme for statistical analyses. By using the frequency of intake of the different food items over 7 days and the estimated portion sizes (determined by Charlton *et al.*[15]), it was possible to calculate the total sodium intake per week. The conversion from sodium (Na) to salt (NaCl) was made by using the formula: NaCl (g) = (Na (mg) × 2.542)/1000. Daily salt intake was calculated as 7 days salt consumption values divided by 7.

Participants were trained on the method of urine collection adopted from the guidelines of the World Health Organisation[9]. A single 24-h urine collection was obtained after the first morning voided urine was discarded and then collected until the same time the following day. Participants were counselled on the importance of collecting a complete sample, and provided with a suitable bag and standard containers for collections of the 24-h urine[9]. On completion of the urine collection, each participant was asked a simple set of questions about completeness. The times at the beginning and the end of the urine collection were recorded. The total volume of urine collected was measured using a specially-devised measuring scale. The urinary salt concentration in an aliquot was measured by an ion-selective electrode and the buffered kinetic Jaffe reaction was used for the assay of urinary creatinine (Cobas Integra 400, Roche Diagnostics, Hamburg, Germany). To exclude those with inaccurate urine collections, we limited the analysis to participants with 24-h urine collections >500 ml; urinary creatinine >4.0 mmol/day for women, or >6.0 mmol/day for men[19,20]. For each individual, the 24-h sodium excretion value (mg/day) was calculated as the concentration of sodium in the urine (mg/L) multiplied by the urinary volume (L/day). The conversion from sodium (Na) to salt (NaCl) was made by using the formula: NaCl (g) = (Na (mg) × 2.542)/1000.

Data analysis

Statistical analyses were conducted using SPSS for Windows (Version 22, SPSS Inc, Chicago, USA). A p-value ≤0.05 was regarded as statistically significant. Descriptive statistics was used to present the frequency, percentage, mean, and standard deviation of independent variables such as socio-demographic factors (age, gender, BMI), as well as the

dependent variables (SBP and DBP, and 24-h urinary salt excretion). Normally distributed data were reported as the means and standard deviation (SD) and non-parametric data were reported as geometric means (5^{th}-95^{th} percentile). The *t*-tests were used to compare mean variables between groups. Tukey tests were used to compare mean variables between tertile groups. We used Pearson correlation coefficients to determine the relationship between salt intake (both methods) and blood pressure. Partial correlations (adjusted for gender, age and BMI) were used to determine the strength of the relationship between the salt intake from the questionnaire and the 24-h urinary excretion. The Bland and Altman[21] method was used to evaluate agreement between the two methods. The mean salt intake from the questionnaire and the 24-h urinary excretion were plotted against the difference between the two methods. Assessing agreement was also done by classifying participants into two categories of intake (those reaching the target of <5 gram salt per day and those who did not reach the target) and calculating the percentage of participants correctly classified into the same category and those not.

Ethical approval

Permission to undertake the study was obtained from the Human Research Ethics Committee of the North-West University, Potchefstroom campus (Reference No. NWU-00001-12-A1). The study was carried out in accordance with the Declaration of Helsinki (2002).

Results

Three hundred and thirty six individuals were selected for the study from which a total of 56 individuals were excluded because of suspected incomplete urine collections (n=38), and low urinary creatinine levels (n=18). Since there were only a trend towards significant difference in salt intake between gender for whites based on the questionnaire (p=0.08) and 24-h urinary excretion (p=0.06) and no significant difference in salt intake between gender for the blacks (p=0.19 and p=0.15 respectively) the study population were divided by ethnicity only (data not shown). Characteristics and differences of the 280 participants of white and black ethnicities are indicated in Table 1. There was a significant difference in salt intake based on the questionnaire between the white and black groups (p=0.01) but not for the 24-h urinary sodium excretion.

Table 1: Characteristics of the participants

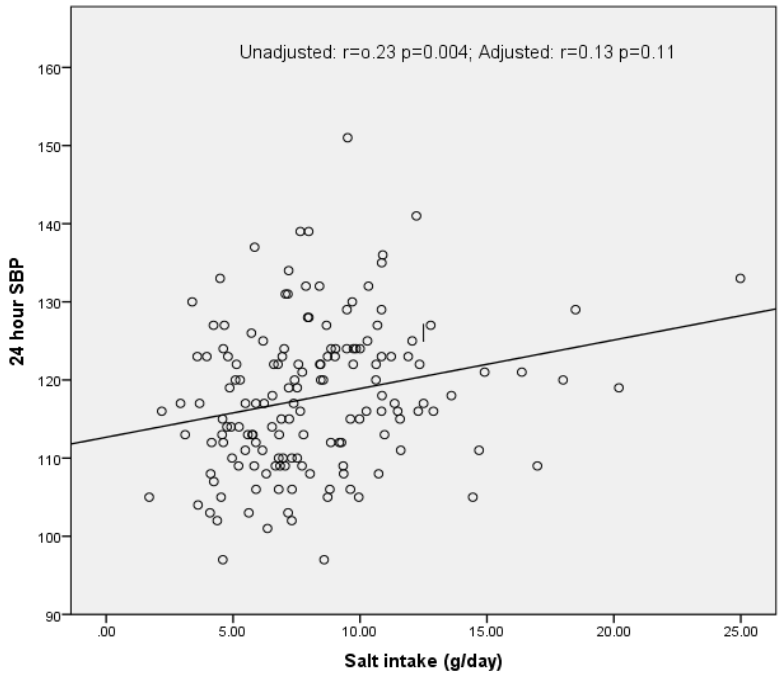
Characteristics	White participants (n=155)	Black participants (n=125)	p-value
Age (years)	25.7 (2.7)	24.4 (3.1)	<0.01
Body mass index (kg /m²)	25.9 [18.9-40.5]	24.7 [17.2-36.9]	0.08
Cardiovascular measurements			
24 hour:			
Systolic BP (mmHg)	118 (9.5)	117 (9.4)	0.53
Diastolic BP (mmHg)	69 (6.3)	70 (6.3)	0.44
Heart rate (bpm)	74 (10.8)	78 (11.8)	0.01
Salt frequency questionnaire			
Sodium consumption (mg/day)	3223.4 (1387.4)	3938.8 (2029.2)	0.01
Sodium converted to salt (g/day)	7.8 (3.9)	8.9 (4.8)	0.01
Biochemical analyses			
24-h urinary excretion			
Sodium in urine (mg/day)	3459.7 (1703.9)	3236.5 (1971.8)	0.31
Sodium converted to salt (g/day)	8.0 (4.2)	7.5 (4.9)	0.31
Creatinine in urine (mmol/L)	9.8 [5.0-20.2]	10.7 [4.8-19.5]	0.12

Normally distributed data reported as mean (SD) and non-parametric data reported as geometric mean (5^{th}-95^{th} percentile)

There was a significant difference between the mean salt intake values of the salt frequency questionnaire and 24-h urinary excretion for the white participants (p<0.01) and for the black participants (p<0.01) (data not shown).

When comparing the salt intake based on the questionnaire and 24-h urinary excretion we found no difference for the white (r=0.07; p=0.40) and black (r=-0.53; p=0.56) participants. After adjustment for age, BMI and gender there were also no correlation in white (r=0.03; p=0.72) and black (r=-0.78; p=0.39) participants (data not shown).

Figures 1 – 4 show the unadjusted and adjusted correlations for salt intake (based on both methods) and blood pressure for white and black participants. Estimated salt intake from the questionnaire significantly correlated with SBP in white participants (r=0.22, p=0.005) before adjustment for covariates. None of the correlation (unadjusted or adjusted) were significant for the black participants (all p>0.05).



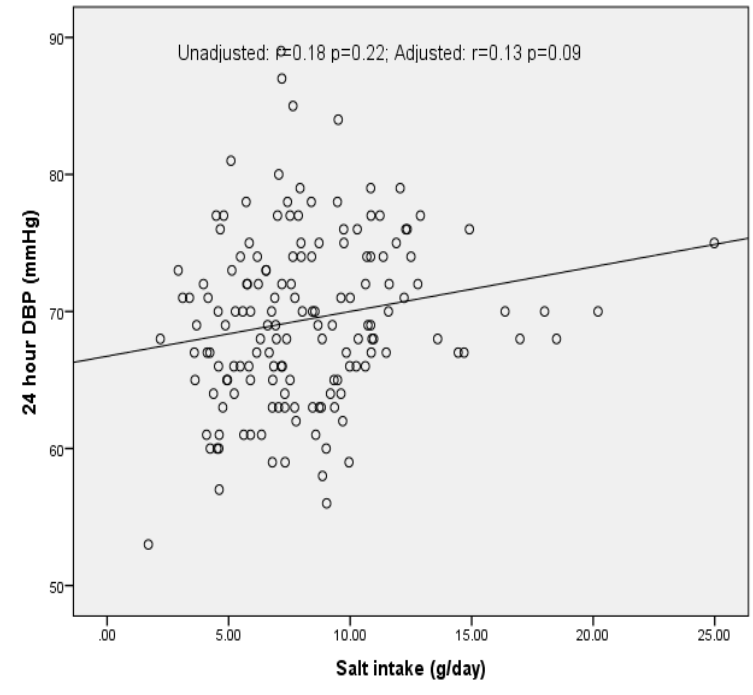


Figure 1: Systolic and diastolic blood pressure of white participants plotted against estimated daily salt intake from the short salt frequency questionnaire
Adjustments were made for age, BMI and gender; SBP - systolic blood pressure; DBP - diastolic blood pressure.

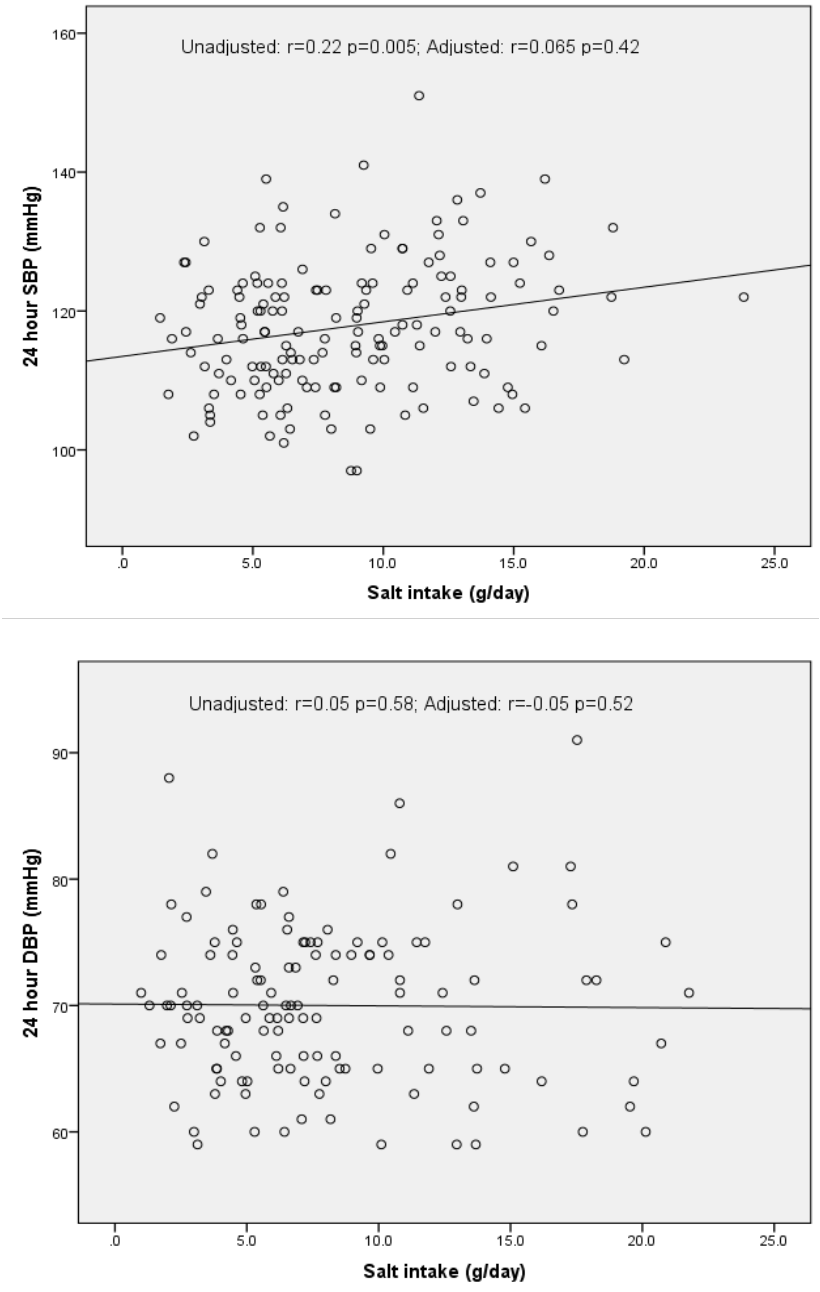


Figure 2: Systolic and diastolic blood pressure of white participants plotted against 24-hour urinary salt excretion

Adjustments were made for age, BMI and gender; SBP - systolic blood pressure; DBP - diastolic blood pressure.

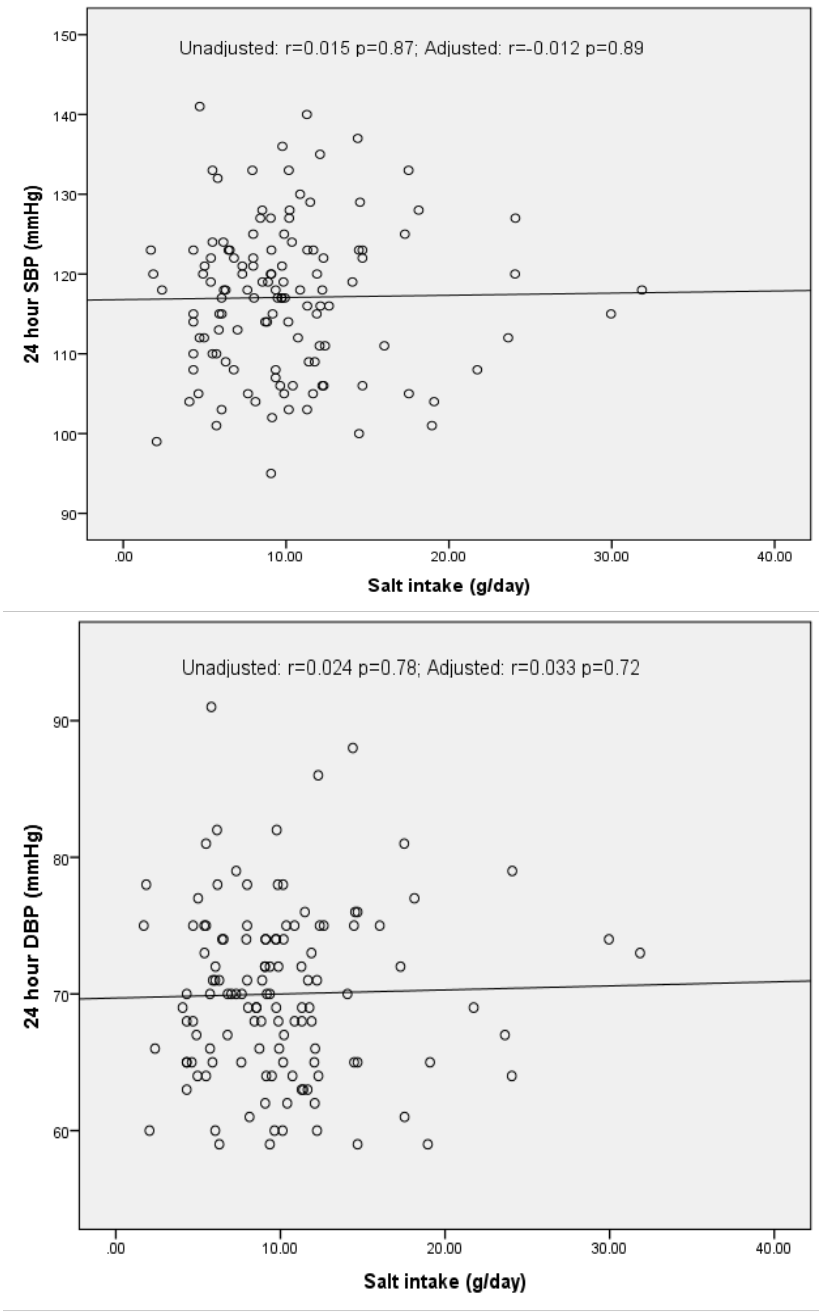


Figure 3: Systolic and diastolic blood pressure of black participants plotted against estimated daily salt intake from the short salt frequency questionnaire
Adjustments were made for age, BMI and gender; SBP - systolic blood pressure; DBP - diastolic blood pressure.

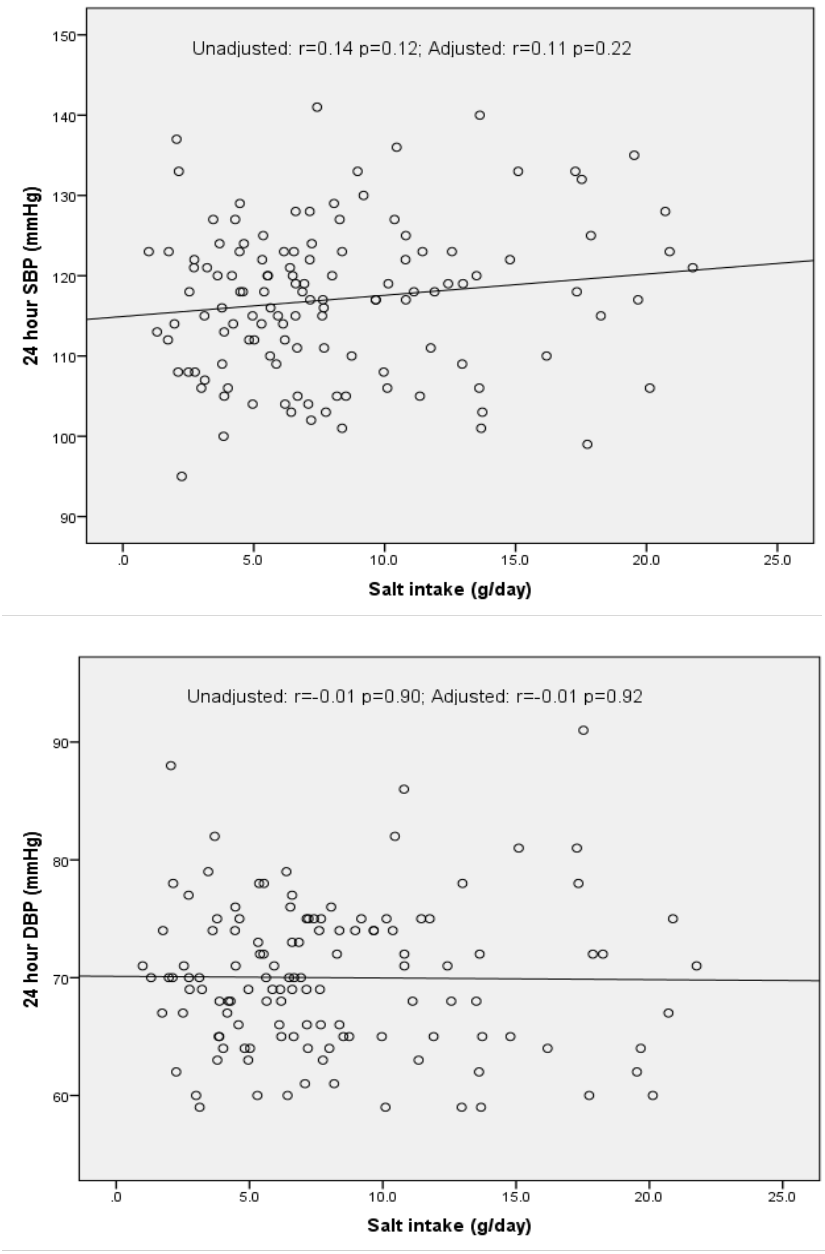


Figure 4: Systolic and diastolic blood pressure of black participants plotted against 24-hour urinary salt excretion.
Adjustments were made for age, BMI and gender; SBP - systolic blood pressure; DBP - diastolic blood pressure.

Figures 5 and 6 show the Bland-Altman plots for salt intake for the white and black participants. For the white group the mean difference in salt intake between the methods was 0.5 g/day, and for the black group -1.9 g/day. Despite these small differences, the limits of agreement were large for both ethnicities. Urinary sodium excretion may estimate salt intake to be 9.6 g/day above or 11.1 g/day below the questionnaire's estimation in the white, and 10.8 g/day above and 18.4 g/day below in the black groups. In both ethnicities we observed less agreement in the methods with higher salt intake.

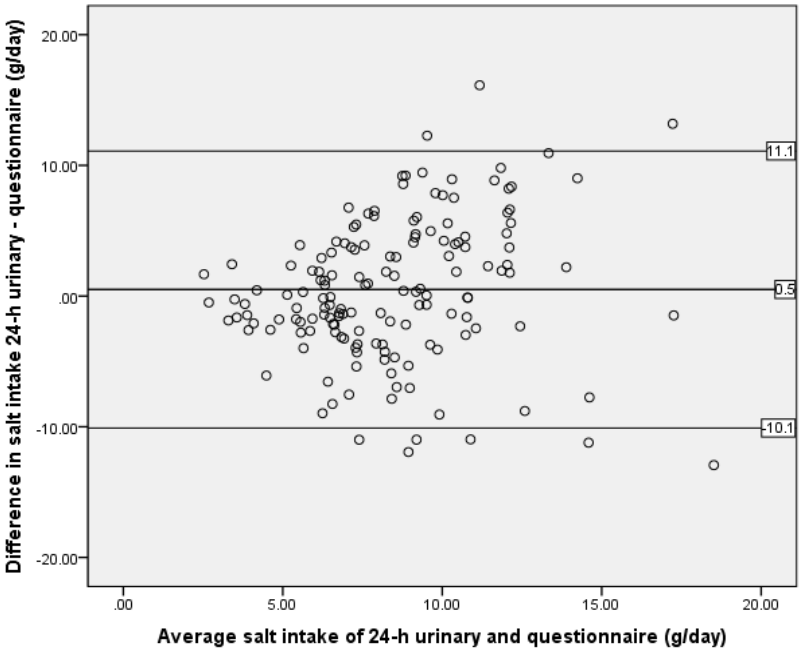


Figure 5: Bland-Altman plot for salt intake with the mean difference for white participants

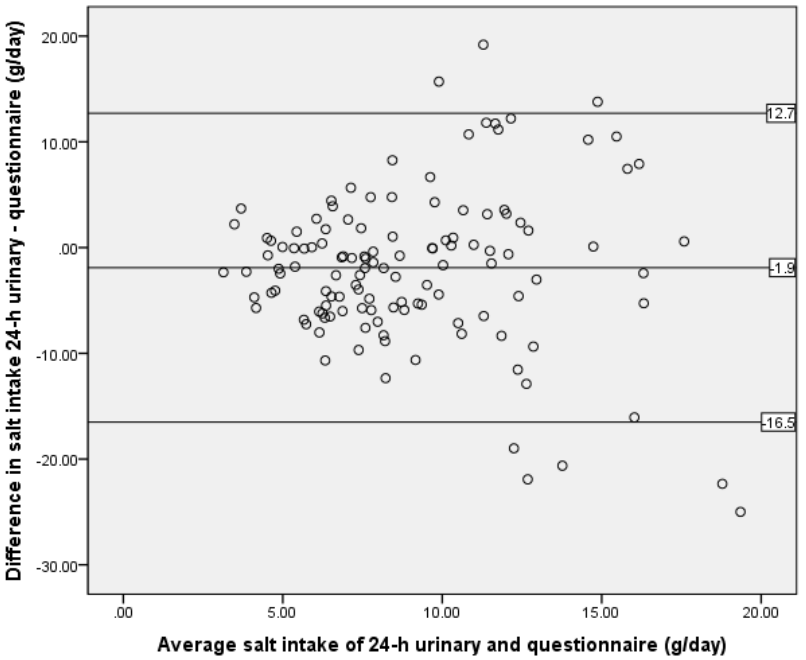


Figure 6: Bland-Altman plot for salt intake with the mean difference for black participants

Table 2 shows the results when categorizing the participants in two groups of meeting the target of less than 5 grams salt per day or not. The majority of the white participants exceeded the target intake based on the questionnaire and 24-h urinary excretion (82% and 81% respectively). In the black population more participants did not meet the target based on the questionnaire (88%) than on the urinary excretion (71%). There was a significant

difference in the number of white and black participants who did not meet the target based on the questionnaire (p=0.03) but not according to urinary salt excretion (p=0.15). The level of agreement between the questionnaire and 24-h urinary excretion of salt in categorising the participants “Meet the target of <5 grams salt per day” or “Do not meet the target of <5 grams salt per day” was analysed using Cohen's Kappa. There was a slight agreement (Kappa = 0.17)[22] for the white participants but no agreement for the black participants (Kappa = -0.06).

Table 2: Participants meeting the target of less than 5 grams salt per day

	White participants (n=155)		**Black participants (n=125)**	
	Meet the target (<5 grams/day)	**Exceed the target (≥5 grams/day)**	**Meet the target (<5 grams/day)**	**Exceed the target (≥5 grams/day)**
Salt intake according to questionnaire	n=28 (18%)	n=127 (82%)	n=15 (12%)	n=110 (88%) *
Salt intake according to 24-h urinary salt excretion	n=29 (19%)	n=126 (81%)	n=36 (29%)	n=89 (71%) **

* - p-value = 0.03; ** - p-value = 0.15

Salt intake estimated from the questionnaire was used to devide the population in tertiles for salt intake from urinary excretion and the BP levels (Table 3). There were a significant difference between all tertiles in both white and black participants for salt intake from the questionnaire (p<0.001). In the white participants there were no significant difference between all tertiles for 24-h urinary salt excretion (all p>0.05). In the same group of participants significant difference for SBP levels were found between tertiles 1 and 2, and 1 and 3 using general linear models (Tukey test) (p<0.006). In the same group a difference was found for DBP between tertiles 1 and 3 (p<0.02). In the black participants there were no significant difference for 24-h urinary salt excretion and BP levels (all p>0.05).

Table 3: Mean 24-h urinary salt excretion and blood pressure levels according to the tertiles of salt intake based on the questionnaire

	Tertiles of salt intake based on the questionnaire (gram/day)							
	White participants (n=155)				Black participants (n=125)			
	Tertile 1	Tertile 2	Tertile 3	p-value	Tertile 1	Tertile 2	Tertile 3	p-value
n	57	58	40		37	34	54	
Salt consumption (salt FQ) Mean (SD)	4.9 (1.1)	8.1 (0.9)	12.5 (3.2)	<0.001†	5.0 (1.3)	8.6 (0.8)	13.9 (4.8)	<0.001†
Range for tertiles (min-max)	1.7-6.7	6.7-9.6	9.7-24.5		1.6-6.7	6.8-9.6	9.7-31.3	
24-h urinary salt excretion Mean (SD)	8.1 (4.0)	9.3 (4.1)	8.5 (4.6)	0.3	8.5 (5.1)	7.3 (4.6)	8.4 (4.8)	0.5
24 hour: SBP (mmHg) Mean (SD)	115 (8.4)	119 (10.5)	120 (8.3)	0.006*	116 (9.0)	117 (8.7)	117 (10.1)	0.9
24 hour: DBP (mmHg) Mean (SD)	68 (5.7)	70 (7.4)	71 (4.4)	0.02**	70 (6.7)	70 (5.4)	70 (6.6)	0.9

SD - standard deviation.

† $p < 0.001$: Difference between all tertiles using general linear models (Tukey test).

* $p < 0.05$: Difference between tertiles 1and 2; 1 and 3 using general linear models (Tukey test).

** $p < 0.05$: Difference between tertiles 1 and 3, using general linear models (Tukey test).

Based on the 42 foods/food groups in the questionnaire we calculated the contribution of each food/food group to the total salt intake. We also combined white and brown bread (Table 4 and Figure 7). The five foods/food groups that contributed most in both ethnic groups were discretionary salt, bread, gravy made with stock or gravy powder, soup and biltong. Figure 7 presents the food groups/items contributing most to the total salt intake. Gravy and soup powders contributed significantly more to the total salt intake of the black participants than the white participants.

Table 4: Contribution of salt from food items to daily salt intake according to salt intake based on the questionnaire

Food items	White (n=155)				Black (n=125)				p-value*
	Rank	Mean %	SD	Max. %	Rank	Mean %	SD	Max. %	
Salt (discretionary)	1	10.1	7.9	35.0	3	8.9	9.0	35.0	0.039
Bread	2	10.0	7.7	66.4	2	9.5	6.0	29.6	0.683
Biltong (beef, game, fish), dry beef	3	10.0	10.3	75.0	7	5.4	7.2	27.0	0.000
Gravy, made with stock or gravy powder	4	5.9	10.1	45.0	1	11.1	12.6	50.0	0.000
Brown bread/rolls	5	5.5	6.8	66.4	6	5.5	4.6	18.2	0.640
Beef sausage (boerewors)	6	4.6	5.1	27.0	8	4.1	4.9	19.0	0.260
Polony/salami/bacon/salami/pork	7	4.5	4.6	31.0	5	5.9	5.1	25.0	0.023
White bread/rolls	8	4.5	5.5	31.9	9	4.0	4.8	26.6	0.556
Breakfast cereal (processed)	9	3.5	6.3	38.1	10	3.9	5.1	24.8	0.039
Meat or chicken pies/sausage rolls	10	3.4	5.1	27.0	11	3.8	5.3	26.0	0.476
Soup (all types)	11	3.4	7.1	46.0	4	6.8	11.8	46.0	0.007
Pizza	12	3.3	4.8	19.6	12	2.9	4.7	20.6	0.689
Cheese	13	3.2	2.6	14.0	16	2.2	2.9	15.0	0.000
Milk (all types)	14	2.9	2.4	10.0	19	1.8	1.7	7.0	0.000
Pasta/noodle dishes with cheese sauces	15	2.3	1.8	9.4	22	1.6	1.6	9.2	0.001
Crisps (Simba, Niknaks, etc.)	16	2.2	2.2	10.0	14	2.4	2.7	16.0	0.809
Chutney/atchar/chakalaka/Worcester	17	2.2	2.6	16.0	20	1.7	2.2	12.0	0.072
Popcorn	18	2.1	3.6	18.0	13	2.5	4.8	26.0	0.940
Potato chips/French fries and potato	19	1.9	1.5	7.0	18	2.0	1.6	9.0	0.855
Chicken – battered (KFC, etc.)	20	1.8	1.8	10.0	17	2.1	2.2	12.0	0.608
Canned vegetables	21	1.8	2.8	17.0	15	2.4	2.9	17.0	0.000
Tinned fish (pilchards, tuna, etc.)	22	1.7	2.4	11.0	36	0.7	1.4	9.0	0.000
Meat and meat dishes (steaks, minced	23	1.7	1.2	6.0	24	1.4	1.3	6.0	0.006
Yoghurt	24	1.7	2.5	23.0	30	1.0	1.3	5.0	0.006
Margarines, all types, also butter	25	1.5	1.4	8.0	25	1.3	1.7	10.0	0.035
Savoury sauces (mushroom, white	26	1.5	1.8	10.0	34	0.8	1.6	7.0	0.000
Cookies, biscuits, rusks	27	1.4	1.8	13.6	28	1.1	1.6	10.8	0.430
Aromat/Fondor/mustard	28	1.4	2.0	8.0	31	0.9	1.6	6.0	0.121
Salad dressing/mayonnaise	29	1.2	1.0	4.0	26	1.2	0.9	5.0	0.846
Tomato sauce	30	1.0	1.7	12.0	27	1.2	2.3	14.0	0.934
Breakfast cereal (min processed)	31	1.0	1.5	12.4	29	1.1	1.9	12.4	0.756
Crackers (ProVita, etc.)	32	0.9	1.6	9.9	23	1.4	2.2	9.9	0.110
Other fish and seafood	33	0.9	4.1	51.0	21	1.7	7.7	51.0	0.002
Chocolate sweets and sauce	34	0.9	1.0	7.0	32	0.9	1.3	8.0	0.774
Cake/scone/muffin/puddings/pancake/	35	0.8	0.7	4.3	33	0.8	0.8	4.3	0.362
Marmite/Bovril	36	0.7	1.3	10.0	40	0.3	0.6	4.0	0.007
Eggs	37	0.6	0.4	3.0	37	0.6	0.5	3.0	0.377
Beer and cider	38	0.5	0.5	3.0	38	0.4	0.5	3.0	0.010
Ice cream (all types)	39	0.5	0.6	4.0	41	0.2	0.4	2.0	0.001

Food items	White (n=155)				Black (n=125)				p-value*
	Rank	Mean %	SD	Max. %	Rank	Mean %	SD	Max. %	
Roti/samosa/spring roll/doughnut	40	0.4	0.8	3.6	35	0.8	1.4	8.1	0.007
Peanut butter	41	0.3	0.4	3.0	39	0.3	0.5	3.0	0.374
Peanuts	42	0.2	0.6	4.0	42	0.2	0.4	4.0	0.916
Maas	43	0.2	0.9	6.0	43	0.2	0.7	5.0	0.894

* p-value – difference between white and black population

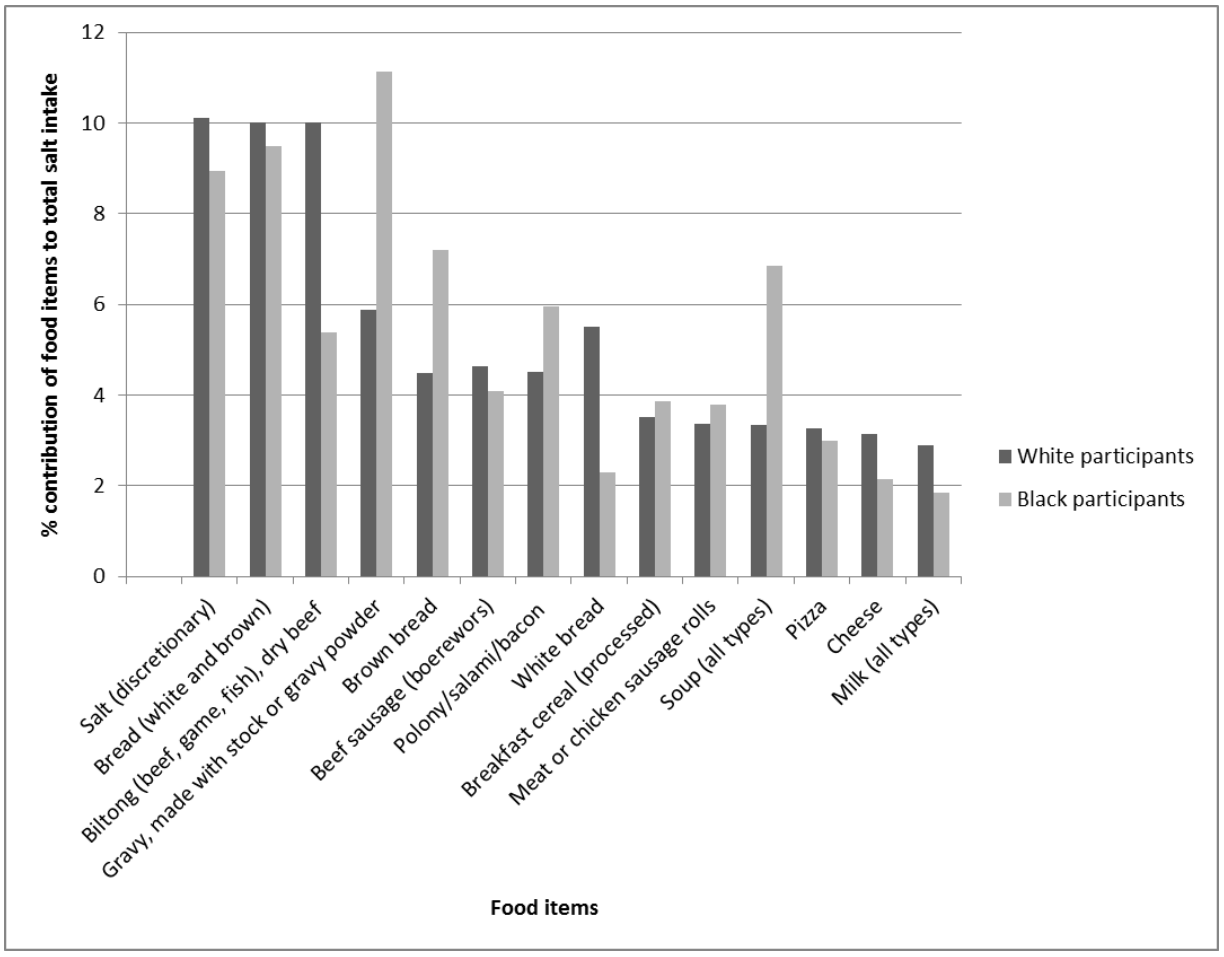


Figure 7: Contribution of food items to total salt intake

Discussion

Assessment of salt intake is very important for the management of elevated BP but accurate measurement of dietary salt intake is difficult especially due to the frequent intake of processed foods by populations[23,24]. Twenty-four hour urinary collection is a challenging method to obtain data of dietary salt intake in large studies or even in the primary healthcare setting. The alternative method, such as a short salt frequency questionnaire, may be useful to assess dietary salt intake of an individual.

In this study we used more than one statistical method to assess the validity of a questionnaire. The test only of significance (correlation) is irrelevant to the question of agreement[21]. We found no correlation between salt intake from the questionnaire and 24-h urinary excretion and no difference between the mean intakes of the two methods. Although we found small differences between mean salt intake between the questionnaire and 24-h urinary excretion (0.5 g/day for white; -1.9 g/day for black). The limits of agreement between these methods are unacceptable to advise that the questionnaire could replace the 24-h urinary excretion method. When participants were categorised into groups who meet the target of <5 grams salt per day or not, the level of agreement between the questionnaire and 24-h urinary sodium excretion of salt was slight for the white participants and no agreement for the black participants[22]. Both the questionnaire and the 24-h urine collection method indicated that the majority of the participants did not meet the target of salt intake, but the lack of agreement implies that it is not the same individuals.

Estimated salt intake from the questionnaire significantly correlated with SBP in white participants (r=0.23, p=0.004) before adjustment for covariates. After the influence of age, gender and BMI had been adjusted for, coefficient became 0.13 and p-value 0.11 (see Figure 1). In contrast, there were no changes in the correlation values between salt intake calculated from 24-h urinary excretion and BP after adjustment.

The usefulness of the questionnaire should however not be underestimated, since we found that, especially in the white population a significant increase in both SBP and DBP with increasing tertiles of salt intake according to the questionnaire. This was however, not found for the black group which may indicate that interpretation of the questions may have been different. It confirms the conclusions of the other studies that higher dietary salt intakes are associated with raised BP[2,3].

The WHO[9] protocol recommends 120 participants per cell to determine dietary salt intake on population level. It can be that the total number of participants was not enough for the validation as we had less than 120 participants per cell (we did not distinguish between men and women). The discrepancy between the values obtained by the questionnaire and the urinary excretion highlights the difficulty in quantifying discretionary salt intake in the questionnaire. There are the possibilities of underreporting of discretionary salt intake using this method and the inaccurate or changes in the salt content of processed foods. Despite the fact that various methods exist to identify incomplete collections of 24-h urine it remains difficult to distinguish between complete and incomplete samples[25,26]. In the present study participants were asked to report any missed or spilled collections, less than 500 ml of urine was an indication as under-collection, and assessment of 24-h creatinine excretion were

used to ensure validity. Thus, it was unlikely that incomplete samples in our study were not identified and influenced the correlation. Previous studies similar to our showed the low correlation between questionnaires and urinary estimations of salt excretion and have been reported by other authors[15,27].

Our study confirms a high salt intake in white and black participants. The top ten foods that contribute most to salt in the participants diet in both ethnicities are salt (discretionary), bread (white and brown), biltong, soup powders, gravy (made with stock or gravy powder), sausages (all types), processed breakfast cereals, meat and chicken pies, and canned vegetables. These foods/food groups are corresponding with results of the study conducted Charlton *et al*.[6] in South Africa to identify foods contributing to salt intake in different ethnic groups. One of the staple foods of South Africa namely, bread contributed most to the salt intake due to the high salt content of bread[6]. Results of different studies worldwide showed similar type of foods contributing to the total salt intake. According to the data of the UK Food Survey collected in 2000, bread, baked goods and breakfast cereals were accounted for the biggest proportion (38%) of total salt intake. The second source (21%) came from meat products (including all processed meats)[28]. Estimates of salt intake from a survey conducted in 1994–96 in the United States showed a similar pattern: cereals and baked goods >16% contribution and meat products >13% contribution to total dietary salt intake[29].

The foods identified contributing the most to total salt intake in our study are corresponding with the list of food categories in the new South African Regulation on salt reduction targets for the food industry[30]. These foods are bread, breakfast cereals, margarines and fat spreads, savoury snacks, processed meats and raw-processed meat sausages, dry soup and gravy powders and stock cubes.

Conclusion

The application of the short salt frequency questionnaire may be helpful in epidemiological studies evaluating the foods contributing to the total salt intake, monitoring average salt intake of a population and assessing the proportion of the population not meeting the target of less than 5 gram salt intake per day. It cannot, however be used to assess the salt of an individual. To correctly quantify the salt intake of an individual the 24-h urinary sodium excretion should be used. Alternatively, a random spot urine sample (using the Kawasaki method) can be considered as recently suggested in the literature[31].

Our findings confirm the high salt intakes of young individuals, highlighting the importance of population-based strategies to lower consumption. We also confirmed that both discretionary salt and specific foods, as indicated in the Regulations contribute most to total intake. The

National Department of Health and the South Africa Heart and Stroke Foundation are currently planning strategies and intervention programs to reduce salt intake of the population to less than 5 grams per day. Our findings will assist these organisations to focus on specific foods/food groups in their efforts. Decreased salt intake will contribute to a decrease in the elevated BP of the population. A decrease in the prevalence of elevated BP will ultimately lead to a tremendous cost saving for the country due to the consequences of hypertension namely stroke and CVD[32].

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Chapter 4: Article 2

4.1 Relationship of knowledge, attitude and behaviour to salt with 24-hour urinary salt excretion and blood pressure profiles in normotensive South African adults

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Abstract

Aim: We compared the 24-hour salt excretion and 24-hour blood pressure profiles of normotensive white and black individuals in terms of their knowledge, attitude and behaviour towards dietary salt intake.

Methods: Questionnaires describing knowledge, attitude and behaviour, 24-hour blood pressure measurements and single 24-hour urine samples were obtained from 295 white and black participants from a town in North West province of South Africa.

Results: No differences in blood pressure levels and urinary salt excretions were found between those who describe their knowledge and attitude towards salt intake (all $p>0.05$) amongst the women and men of both ethnic groups. Also, no differences were found between those who indicated that a diet high in salt causes health problems, including high blood pressure, and those who did not (all $p>0.05$).

For white women who describe their behaviour as leaning towards adding salt to food at the table, there was a significant difference in their diastolic blood pressure levels ($p=0.05$). There was a lower salt excretion in the women who answered “yes” to the question of whether they “Avoid eating out” *vs.* those who answered “no” ($p=0.03$). White men had significantly lower systolic blood pressure levels ($p=0.04$) in the group who responded “rarely” to the statement that they “Add salt to food at the table” than those who said that they do so “sometimes” or “always”. In contrast to their white counterparts, black women who described behaviour towards avoiding eating out, showed a higher salt intake ($p=0.04$).

Conclusion: The knowledge and attitude of the women and men of both ethnic groups do not reflect in the findings regarding their salt intake and blood pressure. Only behaviour regarding “adding salt to food at the table”, “avoiding processed foods”, “checking salt content on labels”, and “avoid eating out”, to some extent correlated with their salt intake and

their blood pressure. In addition, our study confirmed that the high salt intake of South Africans of 7.5 to 9.5 grams per day which is higher than the recommended <5 grams per day.

Keywords: Salt, Sodium, Urinary sodium excretion, Knowledge, Attitude, Behaviour

Introduction

Elevated dietary salt intake is one of the risk factors in developing hypertension, as described by the Institute of Medicine US[1]. There is strong evidence that an excessive amount of salt added to food will increase blood pressure in both normotensive and hypertensive individuals[2-4]. The average salt intake in most countries around the world is approximately 9 to 12 grams per day (equal to 3600-4800 milligrams of sodium)[5] including South Africa[6-9]. Currently, the recommendation by the World Health Organization (WHO)[10] and the South African Department of Health[11] is for adults to reduce their salt intake to less than 5 grams per day (2000 milligrams of sodium). One of the most contributing source of salt in the diets in developing countries is discretionary salt (added at the table or during cooking)[5]. Charlton *et al.*[6] found discretionary salt use by South Africans between 33% and 46% of total salt intake for three different ethnic groups. This is a much higher contribution than that reported in studies in Western countries where the highest percentage of dietary salt mostly stems from processed foods (75% to 85% of total salt intake)[12].

The twenty-four hour (24-h) urinary excretion of salt is currently the 'gold standard' for the estimation of salt intake[13]. In healthy individuals, renal excretion reflects more than 90% of ingested salt[14,15].

Population knowledge, attitude and behaviour could exert an influence on salt consumption and are considered to be manageable and changeable factors[16].

The aim of our study was to compare salt intake (as measured by 24-hour salt excretion) and 24-hour blood pressure profiles of normotensive white and black adult individuals in terms of their knowledge, attitude and behaviour towards dietary salt intake.

For the purpose of this study we use the term salt instead of sodium unless otherwise specified.

Methods

The study design is cross-sectional and is nested in the baseline phase of the African Prospective Study on the Early Detection and Identification of Cardiovascular Disease and Hypertension in South Africa (African-PREDICT) study. The study assesses and compares normotensive and apparently healthy white and black South Africans in terms of their cardiovascular, biological and psychosocial profiles.

Participant selection and recruitment

Individuals aged 20-30 years who are residents of the Potchefstroom area were eligible for inclusion in the study. Potential participants signed an informed consent form before commencing with data collection. Participants were included if they were apparently healthy and tested normotensive, uninfected with HIV, not using medication for chronic diseases and had no current or history of chronic diseases, for example, cancer or diabetes. Recruitment was carried out by means of field workers, invitations and advertisements. Depending on the screening results, those who complied with the inclusion criteria were invited to participate in a research project with a more detailed assessment of their health.

Data collection

The study was carried out at the clinic of the Hypertension in Africa Research Team (HART), North-West University. Data collection included a physical examination and blood pressure measurements of participants, who were individually interviewed based on questionnaires about knowledge, attitudes and behaviours related to salt intake, followed by a single 24-h urine collection. The first set of these activities was conducted at the time of the clinic visit with the urine collection scheduled to be completed within next the few days.

The physical examination comprised the measurement of their body weight using calibrated SECA portable electronic scales (Germany) and their height using a calibrated portable stadiometer SECA 213 model (Germany) to the nearest 0.1 kg and 0.1 cm respectively. Subsequently, their body mass index (weight (kg)/height (m^2)) was calculated. Systolic and diastolic blood pressure (BP) was measured over 24 hours with the CardioXplore ambulatory blood pressure monitor (Meditech, Hungary) according to the South African Hypertension Guidelines 2011[9].

Participants were instructed regarding the method of urine collection adopted from the World Health Organization/Pan American Health Organization (WHO/PAHO)[13]. A single 24-h urine collection was obtained after the first voided urine in the morning had been discarded and then collected until the same time the following day. Participants were counselled on the importance of collecting a complete sample, and were provided with standard containers for 24-h urine collections[13]. Each participant was provided with a suitable bag to carry and protect the containers from spillage and to avoid embarrassment. On completion of the urine collection, a simple set of questions about completeness of the samples was posed to each participant. The times at the beginning and the end of the urine collection were recorded. After the urine sample had been collected, the volume of the sample was measured. The urinary sodium concentration

in an aliquot was measured by an ion-selective electrode and the buffered kinetic Jaffe reaction was used for the assay of urinary creatinine (Cobas Integra 400, Roche Diagnostics, Hamburg, Germany). The urine samples were stored at –20°C until analysis. To exclude those with inaccurate urine collections, the analysis was limited to participants whose 24-h urine collections were >500 ml and the urinary creatinine > 4.0 mmol/day for women, or > 6.0 mmol/day for men[17,18]. For each individual, the 24-h sodium excretion value (mg/day) was calculated as the concentration of sodium in the urine (mg/L) multiplied by the urinary volume (L/day). The conversion from sodium (Na) to salt (NaCl) was made by using the formula: NaCl (g) = (Na (mg) × 2.542)/1000.

For the purpose of this study, the questions about knowledge, attitude and behaviour were adapted from the WHO/PAHO protocol for the determination of the level of salt intake in the population[13]. The questionnaire contained nine questions; four related to knowledge of personal consumption, recommended daily intake and possible harmful effects of salt and five questions assessed attitudes and behaviours regarding reducing salt intake. The participants answered according to a range of different scales such as “rarely, sometimes, often”, “yes, no” and “too much, right amount, too little”.

Statistical data analysis

All questionnaire data were captured electronically using Microsoft EXCEL® and exported to the SPSS™ for Windows (Version 22, SPSS Inc., Chicago, IL) for statistical analyses. Descriptive statistics were used to calculate frequencies, percentages, means, and standard deviations of independent variables such as socio-demographic factors (age, gender, BMI), as well as dependent variables (SBP and DBP, and 24-h urinary salt excretion). Normally distributed data are reported as a mean (SD) and non-parametric data as a geometric mean (5^{th}-95^{th} percentile). *T*-tests and ANOVAs were used to compare characteristics between different salt intake groups. The relationship of knowledge, attitude and behaviour regarding 24-h urinary salt excretion and BP levels were investigated by using ANCOVA by means of the general linear model (GLM) univariate procedure which can be applied for both categorical and continuous variables (taking into account covariates). A $p<0.05$ indecated the statistical significance.

Ethics

Permission to undertake the study was obtained from the Human Research Ethics Committee of the North-West University, Potchefstroom campus (Reference No. NWU-00001-12-A1). The study was carried out in accordance with the Declaration of Helsinki (2002).

Results

Three hundred and twenty two individuals were included in the study, of which a total of 27 individuals were excluded, some because of suspected incomplete urine collections (n=23), and four with inadequate urinary creatinine levels. The characteristics and differences of 295 women and men of white and black ethnicities are presented in Table 1. We found that the SBP was significantly lower for women than for men in both population groups (all $p<0.001$). The mean 24-h urinary salt excretion was significantly higher among the white men (9.5±4.2 g) than among the women (8.1±4.2 g) ($p=0.038$), with a similar trend among black men (9.1±4.9 g) vs women (7.6±4.8 g) ($p=0.068$). There were no significant differences in the salt excretion and BP levels between black and white women and black and white men (all $p>0.05$, data not shown).

Table 1: Characteristics of the study population

Characteristics	**White**			**Black**		
	Women	**Men**	**p-value**	**Women**	**Men**	**p-value**
N	91	65		77	62	
Age (years)	25.6±2.6	25.8±2.8	0.640	24.6±3.5	24.5±2.9	0.781
Body mass index (kg /m²)	24.8(18.1-38.6)	27.4 (20.2-40.6)	0.006	27.0 (17.2-36.9)	21.8 (17.2-36.9)	<0.001
Cardiovascular measurements						
24 hour:						
SBP (mmHg)	113.8±8.9	123.5±7.3	<0.001	114.1±8.6	120.5±9.1	<0.001
DBP (mmHg)	68.5±5.7	70.7±6.7	0.033	69.3±5.4	70.7±7.5	0.193
Heart rate (bpm)	77.0±10.0	69.9±10.8	<0.001	83.8±9.1	69.0±8.9	<0.001
Biochemical analyses						
24-h urinary excretion						
Sodium in urine (mg)	3222.7±1688.4	3793.9±1668.7	0.038	3024.0±1922.7	3635.2±1976.5	0.068
Sodium converted to salt (g)	8.1±4.2	9.5±4.2	0.038	7.6±4.8	9.1±4.9	0.068
Creatinine in urine (mmol/L)	8.5 (4.5-14.2)	12.2 (6.5-18.3)	<0.001	8.5 (14.2-14.8)	12.1 (6.8-18.3)	<0.001

Normally distributed data reported as mean (SD) and non-parametric data reported as geometric mean (5^{th}-95^{th} percentile); SBP-systolic blood pressure; DBP-diastolic blood pressure; W-women; M-men

All of the 295 participants with valid urine samples completed the questionnaire about knowledge, attitude and behaviour related to salt consumption (Table 2 - whites; Table 3 -

blacks). The relationships of knowledge, attitude and behaviour to 24-h urinary salt excretion and SBP and DBP were calculated before and after adjustment for age and BMI.

Description of the levels of knowledge, attitude and behaviour towards salt intake in the white participants (Table 2)

Knowledge: The majority of women and men Indicated that a diet high in salt can cause serious health problems (88% and 91% respectively), but only 36% of women and 35% of men linked a high salt diet to raised blood pressure.

Attitude: A high number of women and men (70% and 80% respectively) believed that reducing dietary salt is highly important and also believed that they consume just the right amount of salt (58% of women and 68% of men).

Behaviour: The majority (92% women and 99% men) said that they like salty foods, and 65% of both genders showed that they always add salt during cooking, although they rarely add salt at the table (54% women and 57% men). Only 24% of the women and 36% of the men indicated that they were trying to reduce their current intake of salt. Of those who reported taking action to reduce their salt intake, 22% and 27% stated that they knew the content of salt in food items, 70% and 73% do not add salt to food at the table and 87% and 64% tried to avoid processed food (women and men respectively).

Relationship between knowledge, attitude and behaviour related to salt consumption and BP levels and 24-h urinary salt excretion in the white participants (Table 2)

Knowledge and attitude: There were no differences in the BP levels between those women and men who answered questions about their knowledge and attitude towards salt intake (all $p>0.05$). Also, there were no differences in urinary salt excretion between those who had identified that a diet high in salt causes health problems, including high BP, and those who did not (all $p>0.05$).

Behaviour: There was a significant difference in the DBP levels in women who described their behaviour as leaning towards adding salt to food at the table. Those who said that they add salt "sometimes" or "always" have a higher DBP than those who answered "rarely" ($p=0.05$). Indeed, in the women's group there was a trend towards significantly lower SBP levels for those who tried not to eat processed food compared those who do not try to do so ($p=0.07$).

Men had significantly lower SBP levels ($p=0.04$) and a trend towards significantly lower DBP levels ($p=0.09$) in the group who responded "rarely" to the statement that they "add salt to food at the table" *vs.* those who said that they do so "sometimes" or "always". In the same men's

group there was also a trend toward significantly lower DBP levels among those who are doing something to control salt intake *vs.* those who do not do so (p=0.08). The levels of DBP were lower in the group who said “yes” to the statement that they do not add salt to food at the table than those who said “no”. Only one man answered “no” to the question: “Do you like salty foods?” therefore this data could not be analysed.

There was a lower salt excretion in the women’s group who answered “yes” to the statement that they do “avoid eating out” compared to these who answered “no” (p=0.03). In the same group there was also a trend towards significantly lower salt excretion levels for those who responded that they “sometimes” add salt to food at the table (p=0.09) and that they check the salt/sodium labels on food (p=0.059).

Table 2: Relationship between knowledge, attitude and behaviour and urinary salt excretion and BP levels among white participants[#]

	White population n=156												
	%		Salt excretion (g/24-h)±SD				SBP(mmHg)±SD				DBP(mmHg)±SD			
	W	M	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*
Knowledge														
Does a high salt diet cause health problems?														
Yes	88	91	8.1±4.3	0.62	9.4±4.2	0.66	114±9.0	0.19	123±7.6	0.48	69±5.7	0.64	71±6.7	0.73
No	12	9	7.4±3.6		10.1±4.0		113±9.2		125±4.4		68±5.6		70±7.2	
If yes, what problems? (Raised Blood Pressure)														
Yes	39	35	8.4±4.5	0.32	9.5±4.0	0.94	113±8.4	0.38	124±7.2	0.16	68±5.2	0.17	71±7.4	0.60
No	61	65	7.6±3.8		9.4±4.5		116±9.6		122±7.5		70±6.3		70±5.5	
Attitudes														
How much salt do you think you consume?														
Too much	25	24	8.3±4.3	0.53	10.6±4.1	0.18	116±11.1	0.27	125±7.1	0.47	69±6.1	0.32	73±6.5	0.52
Right amount	58	68	8.3±4.6		9.5±3.8		113±7.8		123±7.7		68±5.2		70±7.0	
Too little	17	8	6.8±2.3		6.0±6.1		114±9.2		126±3.6		70±7.1		68±4.4	
How important to you is lowering salt in your diet?														
Not important	30	20	7.5±3.7	0.40	9.5±4.1	0.65	114±7.8	0.84	123±7.4	0.95	68±6.1	0.77	68±8.6	0.15
Important	70	80	8.4±4.4		9.5±4.2		114±9.5		124±7.4		68±5.6		71±6.2	
Behaviour														
Add salt to food at table														
Rarely	54	57	7.6±3.6	0.09	9.2±4.1	0.49	113±8.8	0.58	122±6.6	0.04	67±5.2	0.05	69±7.4	0.09
Sometimes	22	14	7.2±3.3		9.6±4.7		114±7.8		129±6.0		70±5.8		75±5.4	
Always	24	29	9.8±5.6		10.0±4.2		115±10.4		124±8.1		70±6.3		71±5.3	

	White population n=156													
	%		Salt excretion (g/24-h)±SD				SBP(mmHg)±SD				DBP(mmHg)±SD			
	W	M	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*
Add salt when cooking														
Rarely	14	12	8.4±5.0	0.13	7.9±3.9	0.15	116±11.9	0.64	124±15.5	0.22	69±5.5	0.72	70±11.7	0.62
Sometimes	21	23	9.7±5.2		7.5±2.9		113±7.7		119±7.6		70±5.9		70±6.4	
Always	65	65	7.5± 3.6		7.5±5.2		114±9.2		120±9.2		70±5.8		71±5.8	
Do something to control salt intake														
Yes	24	36	8.2±4.5	0.79	8.8±4.4	0.35	113±7.4	0.94	125±6.8	0.19	68±5.3	0.74	71±7.6	0.80
No	76	64	8.1±4.5		9.9±4.1		114±9.4		123±7.7		69±5.9		71±6.5	
If yes, what?														
• Avoid processed foods														
Yes	87	64	8.0±4.6	0.65	7.7±4.6	0.99	113±7.5	0.07	124±7.4	0.78	69±6.0	0.28	71±8.0	0.99
No	13	36	9.6±3.6		10.5±3.9		118±12.9		127±5.9		70±8.5		72±7.5	
• Check the salt/sodium labels on food														
Yes	22	27	4.9± 1.3	0.059	8.5±4.3	0.94	110±2.3	0.34	122±9.3	0.38	67.2±3.1	0.35	67±9.1	0.17
No	78	73	9.2± 4.7		8.8±4.7		115±9.2		126±5.9		69.2±6.9		73±6.2	
• Do not add salt at the table														
Yes	70	73	7.5±4.3	0.098	8.9±4.5	0.84	112±7.1	0.71	124±6.9	0.23	67±4.4	0.55	70±7.7	0.08
No	30	27	10.0±4.8		8.2±4.9		116±10.7		127±6.9		72±8.5		76±5.5	
• Do not use salt when cooking														
Yes	30	36	6.9±4.2	0.27	9.3±4.3	0.15	115±9.8	0.33	123±9.1	0.07	69±5.4	0.35	70±8.8	0.33
No	70	64	8.9±4.7		8.4±4.7		113±7.8		126±5.4		69±6.9		72±7.1	
• Avoid eating out														
Yes	44	23	6.2±3.6	0.03	8.4±5.0	0.66	111±6.1	0.27	120±8.5	0.12	67±3.7	0.84	67±9.5	0.19
No	56	77	9.8±4.7		8.8±4.5		116±9.3		126±6.0		70±7.5		72±6.4	

	White population n=156													
	%		Salt excretion (g/24-h)±SD				SBP(mmHg)±SD				DBP(mmHg)±SD			
	W	M	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*
Do you like salty foods (salted peanuts, chips, biltong, etc.)														
Yes	92	99	8.1±4.3	-	9.4±4.1	-	114±9.0	0.15	123±7.4	-	69±5.7	0.19	71±6.9	-
No	8	1	-		-		110±7.9		-		66±5.7		-	

[#]Adjusted for possible confounding effects of age and body mass index; SBP-systolic blood pressure; DBP-diastolic blood pressure; g/24-h-grams per twenty four hour; ±SD-standard deviation;

*p-value for differences between answers to question; W-Women; M-Men

Description of the levels of knowledge, attitude and behaviour towards salt intake in the black participants (Table 3)

Knowledge: The majority of women and men realised that a diet high in salt can cause serious health problems (81% and 76% respectively) but only half of them (53% and 50%) linked a high salt diet to raised blood pressure.

Attitude: A high percentage of women and men (71% and 85% respectively) regarded reducing dietary salt as being very important and also believed that they consume just the right amount of salt (77% of women and 87% of men).

Behaviour: Most of the women and men (87% and 79% respectively) said that they like salty foods, and 78% and 72% indicated that they always add salt during cooking, although rarely add salt at the table (70% women and 69% men). Only 21% of women and 13% of men indicated that they were trying to reduce their current intake of salt. Of those who reported taking action to lower their salt intake, 87% and 64% tried to avoid processed food (women and men respectively), 29% and 39% stated that they check the content of salt on labels of food items, 59% of the women and 38% of the men avoid eating out, and half of both genders (53% and 50%) do not add salt to food at the table.

Relationship between the knowledge, attitude and behaviour related to salt consumption and BP levels and 24-h urinary salt excretion in the black participants (Table 3)

Knowledge and attitude: Knowledge about the effect of a high salt diet on health revealed a trend towards elevated SBP levels in men (p=0.07).

Behaviour: “Avoid eating out” reflected a lower salt intake among black women (p=0.04), accompanied by a trend in lower DBP levels (p=0.07).

Table 3: Relationship between knowledge, attitude and behaviour and urinary salt excretion and BP levels among black participants[#]

	Black population n=139													
	%		Salt excretion (grams per 24-hour)				SBP (mmHg)				DBP (mmHg)			
	W	M	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*
Knowledge														
Does a high salt diet cause health problems?														
Yes	81	76	7.6±4.9	0.99	8.4±4.5	0.55	115±8.8	0.39	121±8.8	0.07	70±5.8	0.64	71±7.0	0.20
No	20	24	7.6±4.2		10.6±5.3		112±7.7		120±10.4		68±4.1		70±9.1	
If yes, what problems? (Raised Blood Pressure)														
Yes	53	50	8.0±4.9	0.52	8.5±4.9	0.79	113±9.1	0.44	119±9.2	0.48	69±6.2	0.52	70±8.4	0.70
No	47	50	7.2±4.8		9.6±5.0		114±8.2		122±8.5		69±4.3		71±6.5	
Attitudes														
How much salt do you think you consume?														
Too much	14	3	6.2±1.8	0.56	5.5±1.4	0.82	115±8.1	0.80	121±3.5	0.91	70±1.6	0.71	74±3.5	0.78
Right amount	77	87	7.8±4.5		9.5±4.8		114±8.7		121±9.4		69±5.2		71±3.5	
Too little	9	10	7.6±5.6		7.9±6.4		113±3.7		118±7.5		70±8.2		70±5.9	
How important to you is lowering salt in your diet?														
Not important	29	15	7.6±4.4	0.96	7.9±3.1	0.81	115±9.8	0.52	121±4.9	0.69	70±6.4	0.43	73±2.9	0.27
Important	71	85	7.6±5.0		9.3±5.2		114±8.0		121±9.7		69±5.1		70±7.9	
Behaviour														
Add salt to food at table														
Rarely	70	69	7.7±4.6	0.64	9.0±4.7	0.18	114±8.3	0.68	120±8.8	0.72	69±5.2	0.50	71±7.4	0.86
Sometimes	23	19	6.8±6.0		7.2±5.2		114±9.8		118±10.7		70±9.4		68±6.2	
Always	7	12	8.6±3.7		12.7±4.4		114±9.2		126±6.5		70±4.3		73±9.6	

	Black population n=139													
	%		Salt excretion (grams per 24-hour)				SBP (mmHg)				DBP (mmHg)			
	W	M	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*
Add salt when cooking														
Rarely	10	5	8.4±5.0	0.97	10.9±4.7	0.82	113±7.6	0.89	123±8.9	0.48	69±5.5	0.69	69±11.7	0.98
Sometimes	12	23	9.7±5.2		7.4±4.2		116±11.9		125±5.8		68±5.9		70±6.4	
Always	78	72	8.4± 3.6		10.0±3.9		113±8.2		123±7.6		69±5.8		71±5.8	
Do something to control salt intake														
Yes	21	13	7.2±4.2	0.71	7.8±2.8	0.59	112±8.4	0.42	122±7.2	0.68	68±5.3	0.44	73±3.6	0.47
No	79	87	7.4±4.9		9.3±5.1		115±8.4		120±9.4		69±5.9		70±7.5	
If yes, what?														
• Avoid processed foods														
Yes	82	88	7.7±4.2	0.12	8.2±2.6	0.73	109±8.5	0.56	120±6.9	0.09	65±6.0	0.88	73±2.0	0.29
No	18	12	4.0±1.4		4.5±0.9		114±7.9		123±7.9		70±4.5		74±5.0	
• Check the salt/sodium labels on food														
Yes	29	39	9.7±16.2	0.11	6.7±4.3	0.55	109±8.3	0.45	120±6.9	0.21	65±6.9	0.23	73±2.1	0.91
No	71	62	5.9±2.4		8.4±2.7		114±7.8		123±7.9		69±4.6		74±5.0	
• Do not add salt at the table														
Yes	59	50	8.4±4.7	0.24	7.7±4.5	0.43	111±9.1	0.69	124±9.8	0.26	67±6.1	0.15	75±5.0	0.53
No	41	50	5.0±1.8		7.9±2.9		115±6.4		120±3.6		71±3.9		72±2.1	
• Do not use salt when cooking														
Yes	18	25	7.0±4.2	0.68	7.5±4.2	0.75	117±8.0	0.65	127±12.7	0.23	69±5.4	0.68	77±7.8	0.10
No	82	75	7.0±4.3		7.9±2.7		112±8.0		120±5.1		69±6.9		72±2.1	
• Avoid eating out														
Yes	59	38	8.5±4.7	0.04	6.7±3.0	0.55	112±7.7	0.65	120±6.9	0.21	67±5.7	0.07	73±2.1	0.91

	Black population n=139													
	%		Salt excretion (grams per 24-hour)				SBP (mmHg)				DBP (mmHg)			
	W	M	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*	Women	p-value*	Men	p-value*
No	41	62	4.8±1.8		8.4±2.7		113±8.9		123±8.0		71±4.0		7±5.0	
Do you like salty foods (salted peanuts, chips, biltong, etc.)														
Yes	87	79	7.6±4.9	0.84	8.4±4.7	0.02	114±8.7	0.93	121±8.7	0.39	69±5.5	0.38	71±6.9	0.29
No	13	21	7.3 4.0		11.7±5.1		114±8.4		119±10.4		70±5.5		69±9.6	

[#]Adjusted for possible confounding effects of age and body mass index.

W, Women; M, Men. SBP, systolic blood pressure; DBP, diastolic blood pressure.

*p-value for differences between answers to question.

Discussion

Excessive dietary salt consumption is an important public health issue not only internationally, but also at a national level in South Africa[10,11]. This is the first study, to our knowledge, that has investigated the 24-h urinary salt excretion and 24-h blood pressure profiles of normotensive white and black South Africans in terms of their knowledge, attitude and behaviour towards dietary salt intake.

The vast majority of young normotensive individuals exceeded the target intake of salt of less than 5 grams per day, based on urinary excretion[9-11]. More than 80% of women and men in both study populations knew that salt is detrimental to their health, but their average intake still ranged from approximately 7.5 to 9.5 grams/day. Other South African studies also reported a daily salt intake higher than 5 grams[6-8]. Although limited data is available on the salt intake of South Africans, it is estimated that their salt intake is between 6 and 11 grams per day[6,7]. Monitoring of population salt intake is essential in order to comply with the national Department of Health and WHO target and the requirements for an appropriate reduction of salt intake on a national level. Population-based salt reduction should reduce BP levels, which will lead to a significant overall effect on the health of the population at a lower cost[19].

The results of the present study referring to the evaluation of the knowledge, attitude and behaviour and the actual levels of salt consumption fall in line with the results of recent international studies in a few countries of South America (Argentina, Chile, Costa Rica, and Ecuador), Canada, and Australia[20-22]. They revealed that the levels of knowledge, attitude and behaviour of participants are similar to our findings. Almost 90% of the participants associated excess intake of salt with the occurrence of adverse health conditions, more than 60% indicated they were trying to reduce their current intake of salt, and between 33% and 40% believed that reducing dietary salt is highly important.

In our study, the salt behaviour of the white participants rather than their knowledge and attitude were overall better reflected by 24-h urinary salt excretion and BP levels. Participants who indicated that they “always” or “sometimes” added salt at the table showed that their BP levels and actual salt intake measured by urinary salt excretion was among the higher levels compared to those who responded that they “rarely” do so.

Contrary to the findings among the white population, the black participants’ knowledge, attitude and behaviour regarding salt was not reflected in the urinary salt excretion or BP. Their behaviour to “avoid eating out” reflected a higher and not a lower (as expected) salt excretion. It is possible that the participants may have underestimated their salt intake behaviour at home in order to avoid associating their eating habits with unhealthy behaviours[23].

Although the majority of the participants “rarely” add salt to their food at the table, the majority also indicated that salt is added during preparation of the food. This could contribute to the high salt intake. In addition, they are probably not fully aware of hidden high sources of salt in processed foods and do not realise that salt is present even in foods which do not taste salty [(5)]. A finding of concern is that the majority of participants in our study believed that their salt intake is the right amount or too little. Recently, an international study in nine countries, including South Africa, was conducted by Newson *et al*.[(24)] to study the knowledge and behaviour regarding salt intake in the general population. The authors presented the behavioural stages of changes for salt reduction per country. The vast majority of the South Africans in this study reported that they also thought that their intake was “satisfactory”. Although we did not ask the our participants questions about the stage of potential change, in the international study[(24)] nearly 40% of the South Africans reported having no interest in changing their salt intake and 30% had started to make changes during the last 6 months. That may explain why a very small number of participants in the present study (35% in white and 17% in black groups) reported actions to control their salt consumption. Thus, developing an awareness of the consequences of a high salt intake in South Africa is very important.

Results of the present study of the relationship between knowledge, attitude and behaviour and actual levels of salt consumption could be used to motivate the development of appropriate educational programmes for the public. This should empower individuals to make healthy food choices in order to improve their heart health. Indeed, implementation of such programmes about dietary salt reduction might represent a highly cost-effective way of reducing the systolic blood pressure levels in the population as well as mortality due to cardiovascular disease and stroke[(19)].

Limitations of this study include the cross-sectional approach which means that there may be some uncertainty regarding the causes and consequences of the observed results. It is possible that the salt consumption of the study population has been under- or overestimated because we collected only one 24-h urine sample. Liu *et al.*[(25)] recommended repeated collections in order to represent the variation in salt consumption from day to day. The study was restricted to one regional town, which consequently limits the generalisation of the results.

Conclusion

The main finding of the study is that the knowledge, attitude and behaviour of women and men of both ethnic groups are poorly reflected in their actual salt intake and blood pressure, especially among the black participants. Only behaviours regarding adding salt to food at the table, avoiding processed foods, checking salt content on labels, not adding salt at the table and avoiding eating out to a certain extent reflected salt intake and blood pressure. In addition, this

study confirmed a high salt intake of 7.5-9.5 grams per day by South Africans, which is higher than the recommended less than 5 grams per day.

The current public awareness campaign to decrease salt intake to less than 5 grams per day by the South African National Department of Health and the Heart and Stroke Foundation is commendable. Dieticians, nutritionists and other health professionals can play an important role in this initiative and further education of the public regarding salt intake.

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Chapter 5: Conclusions and recommendations

Conclusions and recommendations

This study explored the relationship between habitual dietary intake of salt, as measured by two different questionnaires, urinary salt measured from a 24-hour urine collection, and BP of a young adult normotensive population residing within the Potchefstroom area of the North West province of South Africa.

This study confirmed a high salt intake of 7.5 to 9.5 grams per day, which is higher than the <5 grams of salt per day recommended by the National Department of Health.

The first two objectives of the study were: to calculate dietary sodium intake using a salt frequency questionnaire and 24-h urinary salt excretion and to determine the agreement between the questionnaire and urinary salt excretion. The calculations obtained from the questionnaire and the 24-h urinary salt excretion are analysed and discussed in Chapter 3. The application of this questionnaire may be helpful in epidemiological studies evaluating the foods contributing to total salt intake, monitoring average salt intake of a population and assessing the proportion of the population not meeting the target of less than 5 gram salt intake per day. It cannot, however be used to assess the salt intake of an individual. To correctly quantify the salt intake of an individual the 24-h urinary sodium excretion should be used. Our findings once again confirm the high salt intakes of young individuals highlighting the importance of population-based strategies to lower consumption.

The next two objectives of the study were to describe the salt behaviour patterns in the study population by means of a salt knowledge, attitude and behaviour questionnaire and to determine the relationship between the results thereof and those of the 24-hour urinary sodium excretion. The data were analysed and discussed in Chapter 4. The main finding was that the knowledge, attitude and behaviour of the women and men of both ethnic groups are poorly reflected in their actual salt intake and their blood pressure levels, especially among the black participants. Only behaviours regarding salt consumption were to a certain extent reflected in the salt intake levels. A very small number of participants in the present study (35 % of the white groups and 17 % of the black groups) reported actions to control their salt consumption. Although the analysis revealed only a few statistically significant values, certain questions of the knowledge, attitude and behaviours from the questionnaire can be extracted and tested in further studies in order to develop a dietary salt assessment instrument. Results of the present study regarding the relationship between knowledge, attitude and behaviour and actual levels of salt consumption could be used to motivate the development of appropriate educational programmes for the public. The outcome should be to empower individuals to make healthy

food choices in order to improve their heart health. Indeed, implementation of programmes about dietary salt reduction might present a highly cost-effective way to reduce the elevated BP levels in the population as well as the mortality due to CVD.

The final objective was to determine the relationship between BP and urinary salt excretion, and the salt frequency and salt behaviour questionnaires. These results were reflected in chapters 3 and 4. Analyses of salt consumption, estimated from the salt frequency intake questionnaire showed that BP levels were significantly lower in the participants from the groups with the lowest salt consumption in relation to those groups with higher intakes. No differences in BP levels and urinary salt excretions were found between those who describe their knowledge and attitude towards salt intake in both ethnic groups. There were significantly lower SBP and DBP levels only amongst the white women and white men who describe their behaviour as leaning towards adding salt to food. Thus, developing an awareness of the consequences of a high salt intake such as elevated BP levels and hypertension in South Africa is very important.

There are methodological limitations to the cross sectional nature of the study that need to be considered. The exposure is merely measured and its association with the outcome is analysed. In a cross sectional study such as the present one, data on exposure and outcome are measured at the same point in time, on the same individuals. The major limitation of cross sectional study designs is that they are unable to confirm causality. However, data obtained from observational studies may still play an important role in describing trends and generating hypotheses about associations.

The type of non-random sampling used may have introduced selection bias which, together with sample size impacts on the generalizability of the findings.

One 24-hr urine collection measurements may not have been sufficient to accurately estimate habitual salt excretion. Indeed, Simpson *et al.* (1983) estimated that fifteen 24-hr urine collections are required to characterise an individual's sodium output with 95 % accuracy. It was not possible in the present study to increase the number of urine collections.

The results are applicable to economically active adults working in North West province. Our data suggests a need to educate South Africans to add less salt to foods and in cooking. It is noteworthy there was a low awareness of salt as being pathogenic in the development of hypertension.

In conclusion, the results reject hypotheses 1 and 2, that there is a significant positive correlation between the estimated salt frequency intake and the 24-hour urinary salt excretion and between the salt behaviours questionnaire and 24-hour urinary salt excretion respectively.

Although, hypotheses 3 and 4 are only partially supported by a few statistically significant values, certain questions regarding the knowledge, attitude and behaviours in the questionnaire can be extracted and tested in further studies in order to develop a dietary salt assessment instrument to estimate habitual dietary salt intake of the individuals. Finally, our results support that the short salt frequency intake questionnaire can be used in epidemiological studies to identify food items that contribute to the total salt intake.

Chapter 6: Bibliography

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Annexure A: Salt frequency intake

African-PREDICT

Subject ID

0	0	-				

Today's date: ☐☐☐☐ ☐☐ ☐☐
year *month* *day*

Salt frequency completed by:

_____

Name of participant: _____

To be completed with the 2nd 24-hour recall (day 24-h urine is returned!)

NUTRITIONAL AND LIFESTYLE HABITS The following questions are about your dietary and life-style habits. All your answers will be strictly confidential							***Office use***	
During the **PAST 7 days (1 week)** did you eat any of the following? IF YES, ASK HOW OFTEN (*if no, circle never*) **[**DO NOT PROMPT THE ANSWER OPTIONS BELOW**]**								
Food item	***NEVER***	NOT EVERY DAY		EVERY DAY				
		1-3 times per **week**	4-6 times per **week**	1 time a **day**	2 times a **day**	3+ times a **day**		
White bread/ white bread rolls	0	1	2	3	4	5		4
Brown/wholewheat bread/ Rolls	0	1	2	3	4	5		
Breakfast Cereal (processed)	0	1	2	3	4	5		
Breakfast Cereal (weetbix, muesli)	0	1	2	3	4	5		
Crackers (ProVita etc)	0	1	2	3	4	5		
Cookies, biscuits, rusks	0	1	2	3	4	5		
Cake/scone/ muffin/ puddings/pancake/fruit pie/koeksister	0	1	2	3	4	5		
Roti/ samoosa/springroll/doughnut	0	1	2	3	4	5		
Pizza	0	1	2	3	4	5		
Pasta/noodle dishes with cheese sauces (macaroni cheese, lasagne, noodle salad etc.)	0	1	2	3	4	5		
Popcorn	0	1	2	3	4	5		
Crisps (Simba and Niknaks etc.)	0	1	2	3	4	5		
Sausage (wors)	0	1	2	3	4	5		
Polony/salami/bacon/salami/pork suasages (processed meat, cooked, smoked and canned)	0	1	2	3	4	5		
Meat or chicken pies/sausage rolls	0	1	2	3	4	5		
Chicken - battered (KFC etc). and chicken burger only	0	1	2	3	4	5		
Meat and meat dishes (steaks, minced meat, cottage pie, mince, meatballs, stew, bobotie, etc.)	0	1	2	3	4	5		20
Gravy, made with stock or gravy powder	0	1	2	3	4	5		
Biltong/dry wors/bokkems	0	1	2	3	4	5		

NUTRITIONAL AND LIFESTYLE HABITS
The following questions are about your dietary and life-style habits. All your answers will be strictly confidential

Office use

During the **PAST 7 days (1 week)** did you eat any of the following?
IF YES, ASK HOW OFTEN
(*if no, circle never*) **[**DO NOT PROMPT THE ANSWER OPTIONS BELOW**]**

Food item	***NEVER***	NOT EVERY DAY		EVERY DAY			
		1-3 times per **week**	4-6 times per **week**	1 time a **day**	2 times a **day**	3+ times a **day**	
Milk (all types, also dairy fruit juice, malted milk, milk shakes)	0	1	2	3	4	5	
Maas	0	1	2	3	4	5	
Cheese	0	1	2	3	4	5	
Yoghurt	0	1	2	3	4	5	
Eggs	0	1	2	3	4	5	
Tinned fish (pilchards/tuna, etc.)	0	1	2	3	4	5	
Other fish and seafood	0	1	2	3	4	5	
Potato chips/french fries and potato salad	0	1	2	3	4	5	
Canned vegetables, incl. Baked beans, tomato paste, sweetcorn, etc.	0	1	2	3	4	5	
Soup (all type, including commercial packets of soup)	0	1	2	3	4	5	
Salad dressing/mayonnaise	0	1	2	3	4	5	
Ice cream (all types)	0	1	2	3	4	5	
Margarines, all types, also butter	0	1	2	3	4	5	
Chutney / atchar/chakalaka / Worcester sauce	0	1	2	3	4	5	
Savoury sauces (mushroom, monkey gland, white,cheese)	0	1	2	3	4	5	
Tomato sauce	0	1	2	3	4	5	
Salt in preparation and/or at table	0	1	2	3	4	5	
Aromat / Fondor /mustard	0	1	2	3	4	5	
Peanuts	0	1	2	3	4	5	
Peanut butter	0	1	2	3	4	5	
Marmite/Bovril	0	1	2	3	4	5	
Chocolate sweets and sauce	0	1	2	3	4	5	
Beer and cider	0	1	2	3	4	5	

Annexure B: Salt behaviour questionnaire

African-PREDICT

Subject ID

0	0	-				

Today's date:

year *month* *day*

Completed by:

_____

Name of participant:

_____

SALT QUESTIONS

1. Do you add salt to food at the table?

Never **1**	Rarely **2**	Sometimes **3**	Often **4**	Always **5**

2. In the food you eat at home: is salt added during cooking?

Never **1**	Rarely **2**	Sometimes **3**	Often **4**	Always **5**

3. How much salt do you think you consume? (READ LIST)

Far too much **1**	Too much **2**	Just the right amount	Too little **4**	Far too little **5**	Refused **6**	Don't know **7**

		3				

4. Do you think that a high salt diet could cause a serious health problem?

Yes	No	Refused	Don't know
1	**2**	**3**	**4**

5. If yes in question 4, what sort of problem? (DO NOT READ THE LIST)

High BP	Osteoporosis	Stomach CA	Kidney stones	None of above	All of above	Refused	Don't know
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**

6. How important to you is lowering the salt/sodium in your diet?

Not at all	Somewhat	Very important
1	**2**	**3**

7. Do you do anything on a regular basis to control your salt or sodium intake?

Yes	No	Refused	Don't know
1	**2**	**3**	**4**

8. If answer is YES in question 7, what do you do? (READ THE LIST)

		YES	**NO**
i.	Avoid/minimize consumption of processed foods	1	2
ii.	Look at the salt or sodium labels on food	1	2
iii.	Do not add salt at the table	1	2
iv.	Buy low salt alternatives	1	2
v.	Buy low sodium alternatives	1	2

vi.	Do not add salt when cooking	1	2
vii.	Use spices other than salt when cooking	1	2
viii.	Avoid eating out	1	2
ix.	Other (specify)	1	2

9. Do you like salty foods eg salted peanuts, crisps, chips, fritos, biltong, dried sausage, etc

Very much **1**	Like it **2**	Not at all **3**	Don't know **4**

Annexure C: Participants consent form

Project title:

African **PR**ospective study on the **E**arly **D**etection and **I**dentification of **C**ardiovascular disease and Hyper**T**ension (African-PREDICT)

Principle Investigator: Prof. Alta Schutte

Participant number:……

I have read the Participant Information Leaflet and have had the opportunity to ask questions and have these answered to my satisfaction.
I understand that my taking part in this study is voluntary and that I can withdraw at any time without having to give a reason and without compromising my relationship with NWU, the study team or any health care I may receive. I agree to thoroughly consider any decision to withdraw from the research as I understand it may affect how reliable the results of the study are.
I consent to having the tests outlined in the Participant Information Leaflet, including the genetic tests and for the results of all tests to be used for the purposes of research. I understand all personal data will be handled with care and remain confidential.
I consent to having the HIV tests discussed in the Participant Information Leaflet and, if tested positive, to have further tests organised by the clinic through the National Health Laboratory Service for confirmation of my status through the clinic Sister and HIV counselling service. All results will remain confidential and data may be used anonymously for research.
I understand that the measures taken as part of this study may change over time as the research team learn new things or as new tests become available. I agree that the team can contact me to discuss any changes to the study.
The nature of the project, the procedures, the possible risk factors and the benefits of taking part in this study has all been explained to me and I have read and understood the statements on Page 2 of this consent form.
I understand that I will not receive any payment to take part in this study.
I declare that I understand the information given to me, I have had the opportunity to ask questions and discuss the project with the study team and/or fieldworker and I agree to take part in the project as a volunteer. I hereby give my consent to be a participant in this study.

Participant:
Full Name..... ..... Signature …….....
Date..... ..... Time.....

Study team member taking consent:
Full Name..... ..... Signature …….....
Date..... ..... Time.....

Witness: **Full Name..... .... Signature**

…….....

Participant Contact Details:
Current Address
.....
Cell Phone Number ..... …....
Home telephone number.....
Work telephone
number.....
Email .....
……..
ID number…….....
Date of Birth.....
Place of employment
.....
Family member #1 Contact Details:
Full Name .....
.....
Relationship to you (mother, father, brother, cousin
etc.).....
Current Address
.....
Cell Phone Number ..... …....
Home telephone number.....
Family member #2 Contact Details:
Full Name .....
.....
Relationship to you (mother, father, brother, cousin
etc.).....
Current Address .....
.....
Cell Phone Number ..... …....
Home telephone number.....

To the subject signing the consent form
You have been invited to participate in the African – PREDICT Study as described in the Patient Information
Leaflet. It is important that you read/listen to and understand the following general principles, which apply to all
participants in our research:

Participation in this project is voluntary.

1. It is possible that you personally will not derive any benefit from participation in this project, although the knowledge obtained from the results may be beneficial to other people.
2. You will be free to withdraw from the project at any stage without having to explain the reasons for your withdrawal. However, we would like to request that you would rather not withdraw without a thorough consideration of your decision, since it may have an effect on the statistical reliability of the results of the project.
3. The nature of the project, possible risk factors, factors which may cause discomfort, the expected benefits to the subjects and the known and the most probable permanent consequences which may follow from your participation in this project, are discussed in the Patient Information Leaflet.
4. We encourage you to ask questions at any stage about the project and procedures to the project leader or the personnel, who will readily give more information. They will discuss all procedures with you.
5. You are also welcome to contact the Health Research Ethics Committee of the Faculty of Health Sciences via Ms Carolien van Zyl at 018 299 2094, Carolien.VanZyl@nwu.ac.za

Annexure D: Ethical approval

NORTH-WEST UNIVERSITY
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Ethics Committee
Tel +27 18 299 4850
Fax +27 18 293 5329
Email Ethics@nwu.ac.za

Prof A Schutte

2012/07/31

ETHICS APPROVAL OF PROJECT

The North-West University Ethics Committee (NWU-EC) hereby approves your project as indicated below. This implies that the NWU-EC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title : African Prospective study for the Early Detection and Identification of Cardiovascular disease and hyperTension. (African-PREDICT study)

Project Leader: Prof A Schutte

Ethics number: N W U - 0 0 0 0 1 - 1 2 - A 1
(Institution | Project Number | Year | Status)

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Approval date: 2012/04/12 **Expiry date:** 2017/04/11

Special conditions of the approval (if any): None

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- *The project leader (principle investigator) must report in the prescribed format to the NWU-EC:*
  - *annually (or as otherwise requested) on the progress of the project,*
  - *without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.*
- *The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-EC. Would there be deviated from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.*
- *The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-EC and new approval received before or on the expiry date.*
- *In the interest of ethical responsibility the NWU-EC retains the right to:*
  - *request access to any information or data at any time during the course or after completion of the project;*
  - *withdraw or postpone approval if:*
    - *any unethical principles or practices of the project are revealed or suspected,*
    - *it becomes apparent that any relevant information was withheld from the NWU-EC or that information has been false or misrepresented,*
    - *the required annual report and reporting of adverse events was not done timely and accurately,*
    - *new institutional rules, national legislation or international conventions deem it necessary.*

The Ethics Committee would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the Ethics Committee for any further enquiries or requests for assistance.

Yours sincerely

Prof Amanda Lourens
(chair NWU Ethics Committee)

Annexure E: Language Editing

Pat Finlay

English Language Editing

pat.finlay.4.editing@gmail.com
P O Box 7118, Greenstone, 1616.
Cell: +27 (0)83 320 7951
Fax: 086 6111 643 (South Africa only)

2nd December 2014

TO WHOM IT MAY CONCERN

This is to certify that I, a native English language speaker, have edited the thesis, **Relationship of salt usage behaviours and urinary sodium excretion in normotensive South African adults,** by Marina Visser, for English style, language, and consistency.

The responsibility to accept or reject suggestions rests with the student.

Thank you for the opportunity to do this.

Sincerely

Patricia-Anne Joy Finlay

Full member of the Professional Editors Group