Studies since 2005 on South African primary schoolchildren suggest lower anaemia prevalence in some regions

Taljaard C, PhD, Graduate; Covic NM, PhD, Senior Lecturer; Van Graan A, PhD, Senior Lecturer
Kruger HS, PhD, Professor; Jerling JC, PhD, Professor
Centre of Excellence for Nutrition, North-West University, Potchefstroom
Correspondence to: Namukolo Covic, e-mail: namukolo.covic@nwu.ac.za
Keywords: iron status, anaemia, independent studies, primary schoolchildren, South Africa

Abstract

The objective of this study was to report on the iron status of South African primary schoolchildren, as reported in independent studies conducted since the last National Food Consumption Survey-Fortification Baseline (NFCS-FB) in 2005. Internet searches were conducted for cross-sectional and randomised controlled trials that reported on the iron status of South African primary schoolchildren, published after the NFCS-FB of 2005. Search engines that were used included Science Direct, Sabinet, PubMed, EBSCOhost (Academic Search Premier, Health Source and Medline) and Web of Knowledge. The search terms in different combinations were "South Africa", "children", "iron", "anaemia", "iron deficiency", "micronutrient", "malnutrition" and "nutritional status". Secondary analysis was carried out on the NFCS-FB data on children aged 7-9 years at provincial level. Outcome measures used were haemoglobin (Hb) and serum ferritin. The search identified four independent studies that were conducted in four different provinces: KwaZulu-Natal, North West, Western Cape and Northern Cape. All four were conducted in low socio-economic areas and selected children with poor iron status for intervention purposes. The studies reported an anaemia prevalence lower than that of the NFCS-FB: 11.5% vs. 14.4%, KwaZulu-Natal; 6.9% vs. 27%, North West; 17.2% vs. 18.8%, Western Cape; and 5.4% vs. 22.2%, Northern Cape. Serum ferritin was more difficult to interpret because different cut-off points were used. Anaemia prevalence, based on Hb concentration in primary schoolchildren, might have improved in some regions since the NFCS-FB. Regular national surveys are recommended to ensure that the iron status of South African primary schoolchildren is kept under surveillance.

Introduction

Anaemia is a worldwide public health problem. More than half of the world's children of preschool age are anaemic.[1] The wide-ranging impact of iron deficiency, with or without anaemia, on human health includes increased fatigability and weakness and greater susceptibility to infection and delayed mental and physical development.[2,3] Anaemia for the age group relevant to this study was defined as haemoglobin (Hb) ≤ 11.5 g/dl and iron deficiency as serum ferritin ≤ 12 µg/l.[2] Those with iron deficiency anaemia would have combined Hb ≤ 11.5 g/dl and serum ferritin ≤ 12 µg/l.

In order to prevent the development of anaemia and its consequences, it is important that the iron status of individuals and populations is monitored. Worldwide, anaemia prevalence is determined by measuring blood Hb. Hb measurement is recommended when surveys relating to public health are conducted, when resources are poor and the prevalence of anaemia is high. Therefore, Hb measurement is the most popular choice when assessing iron status and has been used in the majority of South African surveys.[4] The limitation of Hb is that the measurements only change when iron

deficiency is already severe. Therefore, researchers turn to more sensitive tests, such as serum ferritin, transferrin receptor (TfR) and zinc protoporphyrin (ZPP). Serum ferritin acts as a measure of the amount of iron in body stores, if there is no current infection.[2] The TfR reflects the demand for iron and is less affected by infection than serum ferritin.[2] While serum ferritin has commonly been used as an iron status indicator in South African studies, only a few studies have used TfR and ZPP as iron status indicators in intervention studies.[5,6]

In 2005, almost 28% of South African children between the ages of one and nine years were anaemic,[7] meaning that anaemia was a moderate public health problem.[4] In South Africa, since 1994, three national nutritional surveys in children have been conducted: the South African Vitamin A Consultative Group (SAVACG) in 1994,[8] the National Food Consumption Survey (NFCS) in 1999,[9] and the NFCS-Fortification Baseline (NFCS-FB) in 2005.[10] In the South African field of nutrition, these studies are well known, and in many cases are used as reference material for the development of policies and programmes, such as the vitamin A supplementation programme.

National nutrition surveys include essential information with regard to the nutritional status of South African children, the foods that are purchased per household, and what children consume.

Before 1994, the absence of a national nutritional surveillance programme was the main reason for the lack of data on the prevalence of malnutrition (overnutrition and undernutrition, as well as micronutrient malnutrition) on a national scale.[8] To address this problem, SAVACG was formed in 1993 with the aim of determining the growth and micronutrient status of children younger than six years of age in order to guide the development of intervention programmes.[8] In 1999, the first NFCS was conducted on children between the ages of one and nine years. In contrast with SAVACG, the aim shifted to the usual food consumption of children, nutrient intake and factors that influence food consumption and nutrient intake. Furthermore, anthropometric status was determined, but biochemical measurements were not taken. The results of the NFCS influenced food fortification strategies and nutrition education material.[11]

In 2003, the National Food Fortification Programme was implemented,[12] and the original intention was that the data collected by the second NFCS-FB[10] would serve as the baseline data. However, because the survey was conducted two years after fortification became mandatory, the data do not fully serve as baseline measurements for fortification, but are nevertheless regarded as a useful and valuable reference point. The survey determined the anthropometric and micronutrient status of children between the ages of one and nine years. Because the NFCS survey in 1999 did not report on biochemical status, a 10-year gap exists between surveys that report on iron status. Furthermore, SAVACG included children younger than six years of age only. This means that the only national data on the biochemical micronutrient status of primary schoolchildren are based on the NFCS-FB of 2005. Since then, almost 10 years of mandatory fortification have passed.

The scarcity of national data on primary schoolchildren forces researchers to either consider available data from smaller independent studies (referred to as independent studies), or to make use of older national data. While independent studies are not representative of the population, national data might be outdated. This review aims to report on iron status and anaemia prevalence in primary schoolchildren, as observed in independent studies conducted since the last national study in 2005,[10] and to report on any measure indicative of iron status (serum ferritin, TfR and ZPP) and anaemia prevalence (Hb).

Method

To retrieve publications that relate to iron status in South African primary schoolchildren, a search was conducted for published literature from January 2005 to April 2012. Computerised Internet searches were carried out using Science Direct, Sabinet, PubMed, EBSCOhost (Academic Search Premier, Health Source and Medline) and Web of Knowledge, as search engines. The screening and selection of papers was conducted independently by one of the authors, and an independent literature search performed by a librarian of North-West University to ensure that all relevant articles were found.

Search strings included combinations of the terms "South Africa", "children", "iron", "anaemia", "iron deficiency", "micronutrient", "malnutrition" and "nutritional status" (Figure I). Reference lists of applicable articles were hand searched for relevant articles, and researchers known to work in the field of iron status in South Africa contacted with regard to any recent unpublished data.

Papers were screened on the basis of title and abstract. Once potentially relevant literature was identified, full-text articles were retrieved and reviewed for inclusion on the basis of the predetermined inclusion criteria. To be included, publications (cross-sectional or randomised controlled intervention studies) needed to provide information on iron status or anaemia prevalence in primary schoolchildren in the age range of 5-11 years. Only baseline results of randomised controlled intervention studies were used. Baseline data for randomised controlled intervention studies were categorised into before and after screening data, depending on data availability. Studies that were published after 2005, but conducted prior to the NFCS-FB of 2005, were excluded. Children had to be apparently healthy. Therefore, studies on children with malaria, cystic fibrosis, tuberculosis, cancer or human immunodeficiency virus were excluded. Furthermore, the studies had to report on iron status indicators, including (serum ferritin, TfR and ZPP) or Hb, the indicator for anaemia. Z-score data (weight-for-age, height-for-age and body mass index-for-age z-scores), if available, were also extracted from studies reporting on these biochemical measures.

If the data of children before screening and after screening were not included in the reviewed research article, the authors were contacted and asked to provide such data. Power calculations were carried out by the included studies to determine the minimum required sample size for intervention effects to be detected. For the purpose of this review, where available, anaemia and iron deficiency data on children before screening were also included. This was based on data provided by the respective authors.

Data extraction was conducted independently. Authors were contacted directly in the event of missing information during the data extraction process. A final number of four studies were included (Figure I).

The NFCS-FB reported on iron status data according to province for children in the age category 1-9 years, and nationally according to age group in the categories of 1-3, 4-6, and 7-9 years.[7] In order to evaluate the data on the 7-9 year age group at provincial level, secondary analysis of the data sets was performed. Furthermore, the NFCS-FB reported z-scores according to the National Centre of Health Statistics reference. The original anthropometric data from the NFCS-FB were re-analysed by Kruger et al,[13] using the reference values of the 2007 World Health Organization (WHO) (WHO AnthroPlus® version 1.0.2 software). These results were used for the purpose of this review.
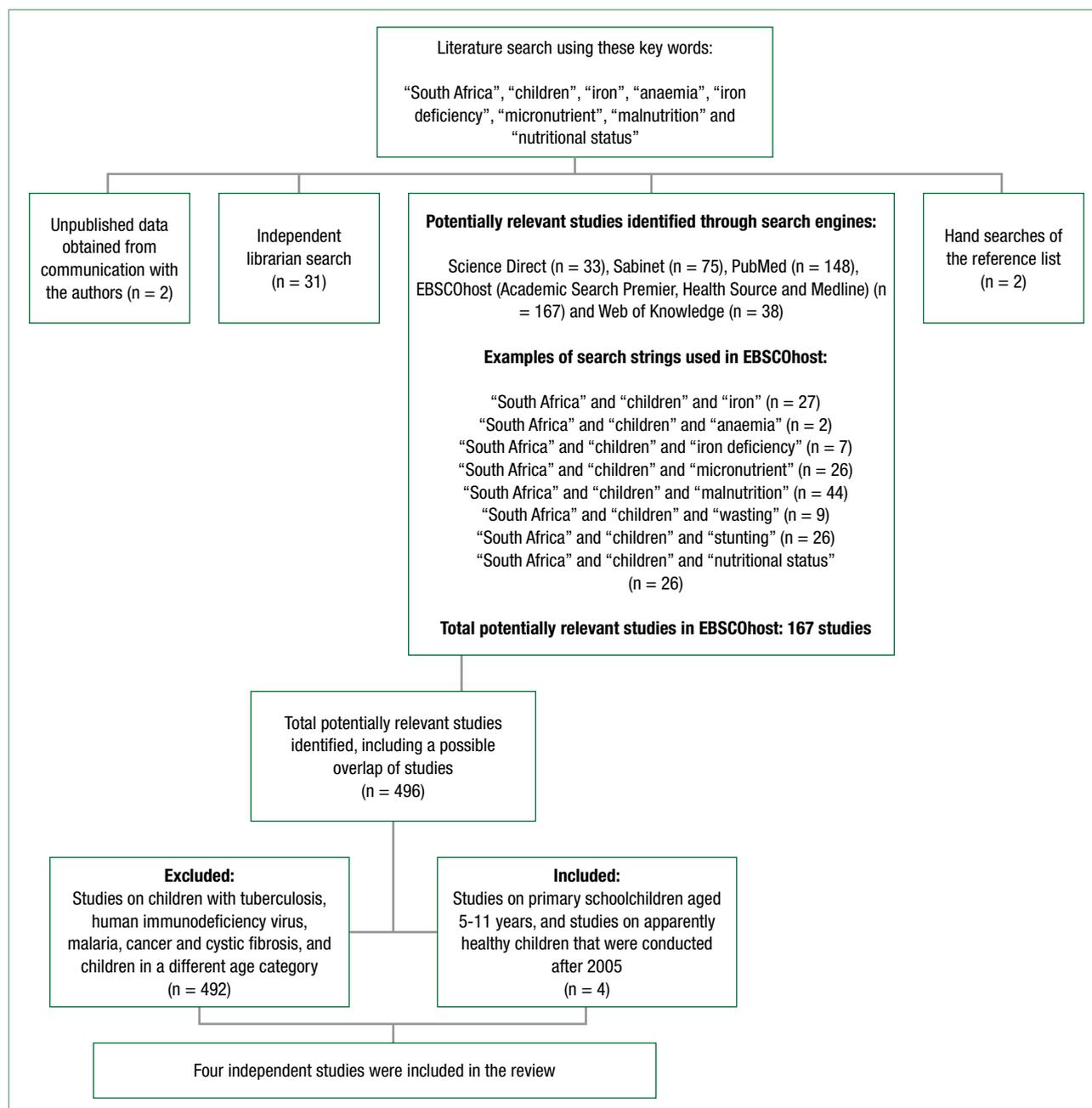
Figure I: Flow chart of the screening process for eligible articles

Results

Four studies conducted in four different provinces met the inclusion criteria (Figure I). Of these, three were randomised controlled intervention studies,[6,14,15] and one cross-sectional study that constituted the baseline data for a larger intervention study.[5] The four studies were reviewed, together with the re-analysed anthropometric data from the NFCS-FB of 2005.[12]

The four independent studies selected children with a poor iron status (Table I).[5,6,14,15] This was primarily because these were intervention studies designed to observe the greatest intervention effects according to their respective aims. Furthermore, the children were dewormed in the four independent studies. Van Stuijvenberg et al[14] dewormed four weeks prior to intervention, and Taljaard[5] within one

week prior to taking the baseline measurements. The remaining two studies dewormed just after taking the baseline measurements.[6,15]

The four studies were conducted in low socio-economic areas. The study authors reported the demographic areas as follows: North West province (low socio-economic peri-urban area),[5] KwaZulu-Natal (low-income rural village),[6] Western Cape (low socio-economic area),[14] and Northern Cape (low socio-economic area).[15] The NFCS-FB included both rural and urban areas. General characteristics of the study population, as well as anthropometric status, are presented in Table II.

Anthropometric status was indicated by weight-for-age, height-for-age, and body mass index-for-age, z-scores. According to the WHO classification normally used for children under five years of age,

Table I: Inclusion criteria, based on iron status, used by the independent studies

Studies	Haemoglobin	Serum ferritin	TfR	ZPP	Notes
Van Stuijvenberg et al[14]	≤ 12.5 g/dl	-	-	-	Hb ≤ 7.2 g/dl excluded and referred to the clinic
Troesch et al[15]*	> 9 g/dl	< 20 µg/l	> 8.2 mg/l	-	-
Taljaard[5]	-	-	414 children with the highest TfR, and then the highest ZPP values, were selected		-
Baumgartner[6]**	-	< 20 µg/l	> 8.3 mg/l	> 70 µmol/mol haeme	Hb ≤ 8 g/dl excluded and referred to the clinic

Hb: haemoglobin, Tfr: transferring receptor, ZPP: zinc protoporphyrin
*: Compliance with either the serum ferritin, or transferrin receptor criteria
**: Compliance with either the serum ferritin, or transferrin receptor, or zinc protoporphyrin criteria

Table II: General and anthropometric characteristics of the children in the four independent studies and the National Food Consumption Survey-Fortification Baseline of 2005

Author	Year and study design	n	Gender		Age (years)	Province	Data reported as	Underweight WAZ < -2	Stunting HAZ < -2	Wasting BAZ < -2
			Boys	Girls						
Van Stuijvenberg et al[14]*	2006, RCT	361	185	176	6-11	Western Cape	%	7.7	14.4	1.1
Troesch et al[15]*	2009, RCT	200	111	86	5-11	Northern Cape	Median (95% CI)	*Treatment group:* WAZ = -1.5 (-1.9,-1.2)	*Treatment group:* HAZ = -1.6 (-2, 1.4)	NR
								Control: WAZ = -1.4 (-1.6, -1.1)	*Control:* HAZ = -1.4 (-1.6, -1.2)	
Taljaard[5]**	2010, Cross-sectional	407	211	196	6-11	North West	%	14	12.8	8.4
Baumgartner[6]**	2009-2010, RCT	321	163	158	6-11	KwaZulu-Natal	%	2.1	6.2	NR
Kruger et al[13]**,***	2005, Cross-sectional	462	NR	NR	7-9	South Africa	%	9.5 (6.8, 12.1)	14.3 (11.1, 17.5)	6.7 (4.3, 9.1)

BAZ: body mass index-for-age z-scores, CI: confidence interval, HAZ: height-for-age z-scores, NR: not reported, RCT: randomised controlled trial, WAZ: weight-for-age z-scores
*: National Centre of Health Statistics reference used
**: World Health Organization reference used
***: Represents the re-analysed National Food Consumption Survey-Fortification Baseline of 2005 data using the World Health Organization reference values

stunting prevalence reported by independent studies and the NFCS-FB was less than 15%.[16] The prevalence of underweight was less than 10% in all of the studies, except Taljaard's (14%).[5] Secondary analysis of the NFCS-FB for children aged 7-9 years per province resulted in too small a number of participants per cell in some provinces (e.g. n = 9 in the Northern Cape). Therefore, the data from the independent studies were compared with the national data for children aged 7-9 years old (n = 462).

Anaemia prevalence (Hb < 11.5 g/dl) varied from 5.4% in the Northern Cape, to 11.5% in KwaZulu-Natal, before screening was performed (Table III).[6,13] After screening was complete, the anaemia prevalence varied between 7.1% in the North West, and 20.9% in KwaZulu-Natal.[5,6] The NFCS-FB reported a higher prevalence of anaemia than independent studies in the provinces, when compared with data before screening (Table III). Owing to the small sample sizes for the NFCS-FB provincial data, the national prevalence for children aged 7-9 years was also included to see if similar observations were found (n = 499). In the studies of van Stuijvenberg et al,[14] Taljaard[5] and Baumgartner,[6] children with elevated C-reactive protein (CRP) levels (> 10 mg/l and > 5 mg/l, respectively) were excluded from the serum ferritin analyses on the preselected children (Table III).

After personal communication with the authors, iron deficiency was re-calculated based on serum ferritin < 12 µg/l. The prevalence of iron deficiency before screening for the independent studies ranged from 3.3% in the Northern Cape[15] to 14.8% in North West province.[5] The NFCS-FB reported the national prevalence of iron deficiency based on the same cut-off point of 4.4% for children aged 7-9 years (Table III). The other variables, TfR and ZPP, although used by some studies in the inclusion criteria, were not reported on by all of the studies and the NFCS-FB, making it impractical to report on the results in this review.

TfR, as a measure of iron status, was not included in the NFCS-FB. Taljaard[5] and Baumgartner[6] reported on iron deficiency prevalence based on TfR values > 8.3 mg/l. Iron deficiency prevalence was reported as 7.6% and 11.5%, respectively, in these studies. Troesch et al[15] and van Stuijvenberg et al[14] reported on the median (95% confidence interval) and mean ± standard deviation of TfR concentrations, respectively, per treatment group, but not as iron deficiency prevalence.

Studies used either 10 mg/l or 5 mg/l as cut-off values for increased serum CRP concentrations as an indicator of low-grade

Table III: Iron status and anaemia prevalence indicated by haemoglobin and serum ferritin concentrations in the four independent studies[a]

| | | Independent studies | | | | | | National Food Consumption Survey-Fortification Baseline of 2005 (by province) | | | | | | |
| | | Before screening[b] | | After screening[c] | | | | | | | | | | |
Province (year)	n	Anaemia prevalence[d] (%)	Iron deficiency prevalence[e] (%)	SF levels per group (µg/l)	Hb per group (g/dl)	Anaemia prevalence (%)	Iron deficiency prevalence (%)	Province	n	Haemoglobin[f] (g/dl)	Anaemia prevalence (%)	n	Serum ferritin levels[f] (µg/l)	Iron deficiency prevalence (%)
Western Cape (2006)	361	Data not available	Data not available	Control 20.4 (5.2,37.7) Tx 1: 22.5 (5.9, 49.4) Tx 2: 19.2 (5.6, 44.2) Tx 3: 20.1 (7.2, 44.9)	Control[g] 11.87 ± 4.9 Tx1: 11.85 ± 5 Tx 2: 11.90 ± 5 Tx 3: 11.90 ± 4.4	17.2	23.1	Western Cape	32	12.4 (12.1-12.7)	18.8	24	46.4 (34.3-58.5)	4.2
Northern Cape (2009)	200	5.4	3.3	Control[h] 19.4 (18.6, 21.8) Tx: 18.5 (17.1, 21.1)	Control[h] 12.6(12.3-12.8) Tx: 12.5(12.3-12.7)	7.3	Data not available	Northern Cape	9	12.3 (10.9-13.6)	22.2	6	54.3 (31.6-77)	0
North West (2010)	407	6.9	14.8	30.56 ± 22.44	12.65 ± 0.96	7.1	15.7	North West	37	12.1 (11.8-12.4)	27	35	33.9 (24-43.8)	2.9
KwaZulu-Natal (2009)	321	11.5	7.3	Control[i] 19.46 (3.8, 62.8) Tx 1: 21.46 (3.1, 73.1) Tx 2: 19.5 (3.8, 68.9) Tx 3: 20.0 (3.9, 72.3)	Control[i] 12.06 ± 0.85 Tx 1: 12.04 ± 0.78 Tx 2: 12.09 ± 0.73 Tx 3: 12.16 ± 0.88	20.9	20.6	KwaZulu-Natal	97	12.4(12.1-12.7)	14.4	90	56.5 (48.3-64.8)	2.2
								National Food Consumption Survey-Fortification Baseline of 2005 (national)						
								National data	499	12.3(12.2-12.4)	18.6	430	46.3 (42.1-50.5)	4.4

Hb: haemoglobin, SF: serum ferritin, Tx: treatment

a: Data presented for children aged 7-9 years

b: Available children at the study site

c: The number of children selected according to a power calculation

d: Anaemia indicated as haemoglobin < 11.5 g/dl

e: Iron deficiency indicated as serum ferritin < 12 µg/l

f: Median (tenth and 90th percentile)=

g: Mean ± standard deviation (and all such values)=

h: Median (95% confidence interval)=i: Median, minimum and maximum

j: Mean (confidence interval)

inflammation. Low-grade inflammation was present in all of the independent studies in less than 8 % of the study samples.

Discussion

This review included four independent studies that reported on iron status and anaemia prevalence in primary schoolchildren in four different provinces of South Africa after the last NFCS-FB in 2005. These studies included large study samples, and were conducted on similar age groups and in low socio-economic areas. In order to evaluate the most comparable data from the NFCS-FB, only children aged 7-9 years were included in this review. Further stratification of the anthropometric data from the national sample to the provincial data yielded groups that were too small. Therefore, the national data of children aged 7-9 years were considered.

The prevalence of wasting, stunting and underweight in the independent studies was moderate or low, and it seems that when compared with re-analysed NFCS-FB anthropometric data, the prevalence of wasting and stunting did not differ from the anthropometric status of the children included in the NFCS-FB.

The independent studies reported lower anaemia prevalence than the NFCS-FB. Despite the children being preselected on the basis of having poor iron status in the respective studies, only one study reported higher anaemia prevalence (KwaZulu-Natal)[6] than was reported in the NFCS-FB. Anaemia prevalence data for the Western Cape[14] were available only after screening, and the study reported prevalence similar to that of the NFCS-FB: 17.2% vs. 18.8%, respectively. The study was only carried out three years after the fortification programme commenced, while the remainder of the studies were conducted 6-7 years after the fortification programme was initiated. However, when considering the final samples after screening in studies conducted in the North West and Northern Cape, the NFCS-FB reported anaemia prevalence rates that were more than three times those reported in the independent studies.[6,15]

A higher prevalence of iron deficiency, based on serum ferritin concentrations, was reported in most of the independent studies before and after screening, while the NFCS-FB reported lower prevalences. Differences between serum ferritin concentrations in children with CRP above 10 mg/l and below 10 mg/l in the NFCS-FB were mostly insignificant, except for the rural (p-value 0.05) and tribal (p-value 0.002) areas. While the NFCS-FB did not correct for CRP, the independent studies did this after screening. Therefore, it was expected that the independent studies would report higher prevalences of iron deficiency based on serum ferritin concentrations. For this reason, it would have been more appropriate if pre-screening data were used, were they available.

In order to provide possible explanations for the observed differences in iron status and anaemia prevalence between the independent studies and the NFCS-FB, the roles of infection and inflammation; deworming, selection criteria and the National Food Fortification Programme on iron status in South Africa, will be discussed.

The effect of low-grade inflammation and infection on the iron status indicator, serum ferritin

Acute and chronic infections lead to lower serum iron and higher serum ferritin concentrations. Research by Beard et al[17] suggests that with a low prevalence of clinically defined inflammation (< 10%), there is little influence of inflammation on the distribution of iron biomarkers in large samples. It is still unclear at what point the prevalence of inflammation causes a shift in iron status indicators.[17] An increase in CRP concentration of 10-30 mg/l has been suggested as a cut-off measure for serum ferritin to remain a valid diagnostic marker of iron status.[18] Furthermore, the duration of increase in CRP is generally shorter than that in serum ferritin during the acute-phase response.[18] The concentration of serum iron decreases within several hours of the start of acute inflammation.[19] The decrease in serum iron is quickly followed by an increase in CRP. Serum ferritin reaches its maximum approximately 48 hours after stimulation, while CRP concentrations start to decline 24-48 hours after the onset of inflammation.[19] Given the above information, for this review, estimations of iron status, based on serum ferritin values, were particularly difficult to interpret because of the possible effect of inflammation. The influence of infection on serum ferritin was undeniable. Based on the reported number of children below and above elevated CRP concentrations (CRP > 10 mg/l) in the NFCS-FB, approximately 12% of children had low-grade inflammation nationally. This was above the < 10% suggested by Beard et al[17] for minimal influence on the distribution of serum ferritin in a large population sample. Therefore, it is uncertain what the influence of low-grade inflammation on the prevalence of iron deficiency could have been, based on serum ferritin, since a correction for CRP was not made in the NFCS-FB.

Deworming and the effect on iron status

All of the independent studies dewormed the children prior to, or shortly after, starting the intervention. Children are dewormed in intervention studies to avoid blood loss caused by intestinal worm infestation which negatively influences iron status.[18] The aim of the initial dose (usually albendazole or mebendazole) was to reduce the worm load by > 80%. Unfortunately, re-infection can occur directly after treatment. The likelihood of re-infection emphasises the importance of repeating treatment, especially in communities in which sanitation circumstances do not improve.[19,20]

Stoltzfus et al[21] reported on 3 595 schoolchildren from Zanzibar, 62.3% of whom were anaemic (82.7% associated with iron deficiency). Through multivariate analysis, they determined that 73% of severe anaemia, and 35% of iron deficiency anaemia, could be explained by hookworm infestation. An increase in Hb concentrations can be expected several weeks or months after the administration of deworming medication. Furthermore, the lifespan of a red blood cell is 120 days.[22] Therefore, it is unlikely that deworming could have had a significant effect on the baseline Hb concentration reported in the independent studies.

Representativeness of national data versus data from independent studies

Data from independent studies cannot be extrapolated to larger population groups because of the manner in which the study samples were selected. In addition, extrapolation to what the situation might be at national level was not possible because of the unrepresentative nature of the samples. The inclusion criteria for the independent studies were that children were selected on the basis of having poor iron status. Therefore, it might be expected that the independent studies that were included overestimated the prevalence of observed anaemia. This is further supported when taking into account the prevalence that was reported before screening. As can be expected, anaemia prevalence was lower than it was after screening.

The possible effect of the National Food Fortification Programme on iron status

The higher prevalence of anaemia in 2005 than in 1994 (SAVACG, 1995) raised concerns for nutritionists.[7] Despite national programmes in South Africa, such as the Integrated Nutrition Programme, an increase in anaemia prevalence was found from 1994-2005. In 2003, mandatory food fortification legislation came into effect.[12] The question is: what has its impact been on micronutrient status, and more specifically, with regard to this article, on anaemia?

According to the Foodstuffs, Cosmetics and Disinfectants Act of South Africa (54 of 1972), wheat, flour and maize meal (super, special, sifted and unsifted) are fortified at a level of 35 mg/kg. Iron fortification has been found to be challenging because the compounds with the best bioavailability cause undesirable organoleptic changes in the fortification vehicles.[23] Furthermore, the correct food needs to be fortified with adequate dosages in order for fortification to be effective in a population.18 From a secondary analysis conducted by Steyn et al,[24] it appeared that fortifying the two most commonly consumed staple foods in South Africa meant that micronutrient intake in children was likely to improve. However, randomised controlled intervention trials have indicated that consumption of elemental iron at fortification levels of 35-56 mg/kg for more than five months did not improve iron status in primary schoolchildren.[14,25] Either bread or maize porridge was given as an intervention in the studies, but not in combination. The quantity of added micronutrients was determined according to South African government regulations. Unfortunately, higher levels of elemental iron, as specified by the WHO/Food and Agriculture Organization of the UN, were not included in the intervention groups of the studies that were conducted.[23] It seems unlikely then that the current dosage of low bioavailable elemental iron now being used for fortification could be the reason for the lower prevalence of anaemia.

While micronutrient consultative meetings to address micronutrient deficiency are currently ongoing in South Africa, observations from independent studies conducted since fortification started have been important in highlighting the need for a national study to monitor the actual prevalence of anaemia and to inform policy in South Africa. Independent studies are certainly valuable in painting a picture of what the situation with regard to iron status may be in specific pockets of the population in the country.

Limitations

Current data from independent studies are neither sufficient, nor sufficiently representative, for direct comparisons to be made with the NFCS-FB of 2005. Nevertheless, such data, being the only data available, cannot be ignored. Data from the NFCS-FB that were re-analysed resulted in small sample sizes which further complicated the interpretation of data at provincial level. Data from the NFCS-FB included children from both rural and urban areas in order to provide a clearer picture of anaemia prevalence in the whole country. These limitations make the need for a national survey more important.

Conclusion

Children were selected from four different independent studies on the basis of having a low iron status. Therefore, although the observations suggest that the prevalence of anaemia is not as high as that measured in the NFCS-FB of 2005, the unrepresentativeness of the samples makes it difficult to draw conclusions. Observed serum ferritin concentrations were even more difficult to interpret owing to a correction for CRP that was not made in all of the studies. Independent studies nonetheless provided valuable information on specific pockets of the studied populations in the respective provinces on which reports were made.

The observations made in this review raise a number of questions that warrant a national survey to determine the current iron status of South African children. It is not clear if iron status is improving, or what role, if any, the National Food Fortification Programme may have played in this regard. It seems unlikely that the poor bioavailable iron used as a fortificant would lead to improved iron status. If iron status has improved, which factors are contributing to this? Only a representative national survey could address these questions adequately.

National data are needed to confirm and clarify the observations of the independent studies on iron status. A new national survey is needed to provide up-to-date data on the prevalence of anaemia. Updated information will guide nutritionists, dieticians and policy-makers in focusing their attention where it is needed, and to evaluate the impact of current national programmes.

Acknowledgements

References

1. McLean E, Egli I, Cogswell M, et al. Worldwide prevalence of anaemia in preschool aged children, pregnant women and non-pregnant women of reproductive age. In: Kreamer K, Zimmermann MB, editors. Nutritional anaemia. Basel: Sight and Life Press, 2007; p. 1-12.

2. World Health Organization, Centers for Disease Control and Prevention. Assessing the iron status of populations. 2nd ed. Geneva: World Health Organization; 2007.

3. Gleason G, Scrimshaw NS. An overview of the functional significance of iron deficiency. In: Kreamer K, Zimmermann MB, editors. Nutritional anaemia. Basel: Sight and Life Press, 2007; p. 45-58.

4. United Nations Children's Fund, United Nations University, World Health Organization. Iron deficiency anaemia: assessment, prevention and control [homepage on the Internet]. 2012. c2012 Available from: http://www.who.int/nutrition/publications/micronutrients/ anaemia_iron_deficiency/WHO_NHD_01.3/en/index.html

5. Taljaard C. Iron status, anthropometric status and cognitive performance of black African school children aged 6-11 years in the Klerksdorp area. [Mini-dissertation (MSc)] Potchefstroom: North West University; 2011.

6. Baumgartner J. Interactions between iron and omega-3 fatty acids: effects of deficiency and repletion on brain monoamines and cognition. Zurich: Swiss Federal Institute of Technology (ETH); 2012.

7. Labadarios D, Louw R. Selected micronutrient status, iron status. In: Labadarios D, editor. National Food Consumption Survey-Fortification Baseline (NFCS-FB): South Africa, 2005. Tygerberg: University of Stellenbosch, 2007; p. 447-455.

8. Labadarios D, Van Middelkoop A. Children aged 6-71 months in South Africa, 1994: their anthropometric, vitamin A, iron and immunisation coverage status. The South African vitamin A consultative group (SAVACG), 1995. SA Health Info [homepage on the Internet]. 2006. c2012. Available from: http://www.sahealthinfo.org/nutrition/vitamina.htm

9. Labadarios D. The National Food Consumption Survey (NFCS): children aged 1-9 years, South Africa, 1999. SA Health Info [homepage on the Internet]. 2006. c2012. Available from: http://www.sahealthinfo.org/nutrition/foodconsumption.htm

10. Labadarios D. National Food Consumption Survey-Fortification Baseline (NFCS-FB): South Africa, 2005. Tygerberg: University of Stellenbosch; 2007.

11. Labadarios D, Steyn NP, Maunder E, et al. The national food consumption survey (NFCS): South Africa, 1999. Public Health Nutr. 2005;8(5):533-543.

12. Department of Health. Foodstuffs, Cosmetics and Disinfectants Act, No 54 of 1972. Department of Health [homepage on the Internet]. 2003. c2012. Available from: http:// www.doh.gov.za/docs/regulations/2003/Regulations_Fortification.pdf

13. Kruger HS, Steyn NP, Swart EC, et al. Overweight among children decreased, but obesity prevalence remained high among women in South Africa, 1999-2005. Public Health Nutr. 2011;15(4):594-599.

14. Van Stuijvenberg ME, Smuts CM, Lombard CJ, Dhansay MA. Fortifying brown bread with sodium iron EDTA, ferrous fumarate, or electrolytic iron does not affect iron status in South African schoolchildren. J Nutr. 2008;138(4):782-786.

15. Troesch B, van Stuijvenberg ME, Smuts CM, et al. A micronutrient powder with low doses of highly absorbable iron and zinc reduces iron and zinc deficiency improves weight-for-age z-scores in South African children. J Nutr. 2011;141(2):237-242.

16. De Onis M, Blossner M. World Health Organization global database on child growth and malnutrition. World Health Organization: Geneva; 1997.

17. Beard JL, Murray-Kolb E, Rosales FJ, et al. Interpretation of serum ferritin concentrations as indicators of total-body stores in survey populations: the role of biomarkers for the acute phase response. Am J Clin Nutr. 2006;84(6):1498-505.

18. Zimmermann MB, Hurrel RF. Nutritional iron deficiency. Lancet. 2007;370(9586):511-520.

19. Hall A, Horton, S. Copenhagen Consensus Centre. Deworming [homepage on the Internet]. 2012. c2012. Available from: http://www.copenhagenconsensus.com/sites/ default/files/deworming....pdf

20. Ziegelbauer A, Speich B, Mausezahl D, et al. Effect of sanitation on soil-transmitted helminth infection: systematic review and meta-analysis. PLoS Med. 2012;9(1):e1001162.

21. Stoltzfus RJ, Chwaya HM, Tielsch JM, et al. Epidemiology of iron deficiency anaemia in Zanzibari schoolchildren: the importance of hookworms. Am J Clin Nutr. 1997;65(1):153-159.

22. Shemin D, Rittenberg D. The life span of the human red blood cell. J Biol Chem. 1946;166(2):627-636.

23. World Health Organization, Food and Agricultural Organization of the United Nations. Guidelines on food fortification with micronutrients [homepage on the Internet]. 2012. c2012. Available from: http://www.who.int/nutrition/publications/ micronutrients/9241594012/en/

24. Steyn NP, Nel J, Labadarios D. Will fortification of staple foods make a difference to the dietary intake of South African children? S Afr J Clin Nutr. 2008;21(1):22-26.

25. Van Stuijvenberg ME, Smuts CM, Lombard CJ, et al. Fortifying brown bread with sodium iron EDTA, ferrous fumarate, or electrolytic iron does not affect iron status in South African schoolchildren. J Nutr. 2008;118(6):780-786.