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Full Length Research Paper

Household Asset Index and Total Iron Intake, but not Education, best Predict Iron Status in a Black Population Sample in Gauteng, South Africa

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This paper reports on independent associations of household asset index and education, as components of socio-economic status, on iron status in a black population sample in Gauteng province. The study was cross-sectional, involving 40 men, 184 women (n = 224), randomly selected, based on informed consent. Socio-economic, dietary intake and biochemical data were collected using household socio-demographic questionnaires, a quantitative food frequency questionnaire and a 24 h recall questionnaire and samples of blood. Serum iron, transferrin receptor, ferritin, haemoglobin, haematocrit and mean corpuscular volume were assessed as indicators of iron status. Results indicated high levels of poverty and illiteracy among the participants. Iron intake indicated a mean of 10.88 ± 7.91 mg/day; (13.51 ± 10.20 mg/day for men and 10.31 ± 7.22 mg/day for women). More women below 50 years (43.8%) consumed less than the estimated average requirements for their age group in comparison with women above 50 years (25.0%). More women had low measures of all respective biochemical indicators compared with the men. By age, younger population groups had a higher prevalence of low iron measures than the older age groups. Household asset index, but not education, significantly predicted total iron intake ($p < 0.05$). Education, however, increased the likelihood of consumption being above the Estimated Average Requirement (not significantly, $P > 0.05$). Household asset index and total iron intake were significantly associated ($p < 0.05$) with all biochemical measures, particularly among women. Education level had minimal association with either of the biochemical measures. Household asset index (a proxy measure of long-term socio-economic situation) and total iron intake predict iron status in a population of South Africans.

Key words: Household, socio-economic status, biochemical, Gauteng, South Africa.

INTRODUCTION

A general overview of the nutrition situation in South Africa indicates that both under- and over-nutrition exist. At national level, more than half of the women are either overweight or obese, while children suffer from under-nutrition (Faber and Wenhold, 2007), a situation which has been confirmed by the most recent national study (Labadarios et al., 2008). Micronutrient malnutrition, often termed “hidden hunger” is also a serious public health problem in South Africa, with vitamin A deficiency, iron-deficiency anaemia, iodine deficiency and, currently, zinc deficiency, being cited as the most important micronutrient problems (Faber and Wenhold, 2007). In 2000, an estimated 519 maternal deaths and 3000 or more perinatal deaths were attributed to vitamin A and iron-deficiency anaemia respectively (Steyn et al., 2006a). Food insecurity, whether due to poor food accessibility or availability, is directly related to an inadequate dietary intake and increased levels of stunting, underweight and micronutrient deficiencies

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(Labadarios et al., 2000).

Nutrient intake and consumption for South Africans is compromised by factors such as age, level of education, ethnicity and area of residence, among other factors (Puoane et al., 2002). Many South Africans do not meet their requirements for micronutrients (Steyn et al., 2006a; 2006b; 2006c; Voster et al., 1997, 2010). Iron and zinc intakes are particularly cited as low (Oelofse et al., 2002), and complementary foods consumed especially by infants are of low nutrient density, especially in iron, zinc and calcium (Faber, 2005). Risk factors for iron deficiency, particularly; include low income and a poor diet, among other factors (Kesa and Oldewage-Theron, 2005). There is also wide variation in the availability of different types of dietary iron, which is further complicated by potential interactions with other food components (Fitch, 2007). Lately, socio-economic status has been used to explain some of these differentials (Mackino et al., 2003; Auger et al., 2004). Evidence also supports the view that growing disparities in income and wealth can lead to growing inequalities in health (Gwatkin et al., 2000; Liu et al., 2001). Based on these associations, international organizations such as the United Nations (UN), the World Bank (WB) and the World Health Organization (WHO) give priority to a policy on reducing inequalities in human well-being and health, as is clearly demonstrated by the Millennium Development Goals (MDGs) and several publications of these organizations (World Bank, 1993; WHO, 2000; UN, 2005). Indeed, these global concerns inevitably lead to a need for practical tools to identify the socio-economic status of individuals or households, particularly in developing countries where the prevalence of socio-economic inequalities in health is high.

Although, various socio-economic indicators exist, some do not accurately predict inequalities, and may not be feasible for intervention studies. Use of monetary measures has been preferred by economists because these are easy to measure and are widely understood by the public, but there are practical problems associated with accuracy in quantifying income or expenditure, especially in developing countries. This has led to a search for non-monetary proxies of household welfare, comprising various approaches such as the household asset index (Krieger et al., 1997; Filmer, 1998).

Lack of education is also generally accepted as perpetuating inequality, oppression and discrimination, leading to underdevelopment of human resources (World Bank, 2003). These inequalities translate into poor food access, which in South Africa is seen to match the prevalence of hunger (Gericke et al., 2000) and under-nutrition. In 2005, almost one third of women and children were estimated to be anaemic on the basis of low haemoglobin concentrations (Labadarios et al., 2007), with the highest levels recorded among women living in rural, tribal and informal settings. Similar findings were reported for low ferritin concentrations (Labadarios et al., 2007), the provinces worst affected being Gauteng, Mpumalanga, Limpopo and the Western Cape. Although, it is acknowledged that the prevalence of poor iron status (due to depletion and deficiency) has doubled in South Africa since 1994, it has not been established whether it is associated with education and household asset index, as proxies of longer-term or permanent income (Falkingham and Namzie, 2001).

This study is motivated by the fact that this community was a poverty-stricken community, suffering from chronic food insecurity (Oldewage-Theron and Slabbert, 2010).

Owing to difficulties in obtaining comprehensive data regarding household income and expenditure, this paper reports on the independent associations of household asset index (Morris et al., 2000; Filmer and Pritchet, 2001; Sahn and Stifel, 2003; Oakes and Rossi, 2003); education, as components of socio-economic status; on nutrition inequalities, specifically the iron status of a black population sample of men and women residing in informal settlements in Gauteng region; South Africa. The results of this study may provide policy makers and programme managers with useful information for planning the improvement of iron status in rural areas.

MATERIALS AND METHODS

Study area and design

The study was carried out in three different informal settlements of Gauteng province, including Boipatong, Eatonside and Orange Farms, which were identified by the local government of Gauteng for implementation of this study. According to the national census of 2001, Gauteng is home to about 19.7% of South Africa's population (Provide Project, 2005). Measured by its total current income, Gauteng is the richest province in South Africa. In terms of per capita income, the province also ranks first (Stats SA, 2003a). Despite its relatively fortunate position, the province is nevertheless marred by high poverty rates, inequalities in the distribution of income between various population sub-groups and unemployment, although not to the same degree as are other regions in South Africa.

The study design was cross-sectional, involving a sample size of 224 participants. Using a computer program G-power version 3.1.2, and considering an alpha level of 0.05, a desired statistical power of 0.95, an anticipated effect size (f^2) of 0.15 and a total of 3 predictors, the minimum sample size was 107 participants. Participants were selected randomly, following signed informed consent obtained after a formal meeting convened by the local leaders with the participants in the respective areas. Data were collected on several variables but the only data presented in this paper are those pertaining to education, household assets and nutritional variables (iron intake and status).

The study was also approved by the Witwatersrand University's medical ethics committee for research on human subjects and the protocol was submitted in accordance with the existing policy for research in the institution. The guidelines of the Medical Research Council (SA) for research on human subjects were adhered to.

Socio-economic data

Socio-economic data were collected with the help of trained field assistants. Socio-economic status in this paper is defined in terms of assets of wealth, rather than in terms of income or consumption. The asset information was gathered through use of a household socio-demographic questionnaire. This questionnaire, among other aspects, included questions concerning the ownership of a number of items ranging from an electric stove, gas stove, paraffin stove, microwave, hotplate, radio, television, refrigerator, freezer, bed and mattress, lounge suite and dining suite to a coal stove. Dwelling characteristics, type of water source and toilet facilities were the other factors taken into consideration to characterize household wealth. By use of principal component analysis, household assets for which information was collected were assigned factor scores (Morris et al., 2000; Filmer and Pritchet, 2001), which were standardized in relation to a standard normal distribution. These standardized scores were then used to create wealth quintiles. Measurement of inequality was done by comparing only the richest (as a base category) with other quintiles. The level of formal education was used independently to assess its effect on the participants' iron intake and status. Levels of education were classified from highest to lowest (post-secondary education, college, secondary education, primary education, none). Inequity in education was measured by comparing the highest level with other categories.

Nutritional data

Dietary intake data were collected using a quantitative food frequency questionnaire (QFFQ) as well as a 24 h recall questionnaire to determine dietary intake and food consumption patterns. The QFFQ was validated based on MacIntyre (2002), and the 24 h recall on Oldewage-Theron et al. (2005). Daily intake of iron in food was determined as total iron, heam iron and non-heam iron, and analyzed using the Food Finder® program, based on the South African food composition tables (Langenhoven et al., 1991). Cut-off points used for dietary adequacy of total iron intake were 7.7 mg/day for men below 19 years of age; 6.0 mg/day for men above 19 years of age; 8.1 mg/day for women aged below 50 years and 5.0 mg/day for women aged 50 years and above (NICUS, 2003), and proportions below cut-offs were derived based on the above recommendations. No information was available on recommended daily intakes for haem and non-haem iron and therefore proportions below cut-off for these variables are not presented.

Biochemical data were collected from analyzed samples of blood, drawn by venipuncture from participants with the help of qualified nursing sisters. All the blood samples were drawn between 7 and 10 h to avoid effects of diurnal variation, and kept in vacutainer tubes. Blood samples were drawn for the determination of serum vitamin A, haemoglobin, haematocrit, zinc, serum iron, ferritin, transferrin and total iron-binding capacity. For the purpose of this paper, only data for serum iron, transferrin receptor (TFR), ferritin, haemoglobin (Hb), haematocrit (HCT) and mean corpuscular volume (MCV), known to be indicators of iron intake, have been presented. The blood was separated within two hours of blood collection, and handled by a haematologist under controlled, standardized conditions, according to existing routine procedures. Assays were performed using the following procedures: haematocrit (numeric integration, Coulter counters ABX MICROSCT); haemoglobin (cyanomethaemoglobin colorimetric method, Coulter counters ABX MICROSCT); serum iron (colorimetric, Roche Unimate 5 Iron); ferritin (immunoturbidometric method, Roche Unimate 3 FERR).

Cut-off points used to define low levels included: serum iron 13.0 µmol/L for both sexes; TFR 4 mg/L for both sexes; ferritin 20 µg/L for both sexes; Hb 13.0 and 12.0 g/dl for men and women respectively; MCV <80 fl for both sexes; and HCT 39 and 36% for men and women respectively, based on recommendations (CDC, 2008).

Data analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS, 18.0; SPSS Inc; Chicago, USA). Descriptive statistics (means, standard deviations, confidence intervals) were generated to characterize the population; asset indices were calculated from a list of assets using principal component analysis, used to derive wealth indices which were then used to correlate with the different biochemical indicators of iron intake, adjusting for age and gender.

The dietary intake and food consumption data were captured and analyzed using the computer program of the South African Medical Research Council, the Food Finder®, version 3.0, with the assistance of a qualified dietician.Tests of association were carried out using cross-tabulations and multiple logistic regressions. A p-value of 0.05 was used as the level at which tests were considered significant.

RESULTS

Most of the participants (82.1%) were women, with only 17.4% having been men. The majority were below 60 years of age (Table 1). The age distribution indicated that more than half (60.7%) were of age 19 to 50 years, with a few young (23.7%) and old (14.7%) participants. Two of the women participants did not report their age. The majority of the households (55.4%) consisted of 1 to 5 persons, most (87.1%) of whom permanently resided in the settlements at the time of the study. More than half (66.5%) the participants lived in zinc/shack type of housing, with only 24.1% owning houses built from brick. The other forms of housing reported were clay (2.2%), grass (0.4%) and other forms not clearly defined (0.4%).

The majority of the participants (88.0%) had access to tap water which was either outside the house or within the yard. Other sources of water reported by the participants included spring/river/dam (1.3%), borehole (0.4%) and some reported fetching water from elsewhere (8.5%). Although the majority (70.1%) had a toilet facility using the flush/sewerage system, some still used rudimentary methods, including the bucket and hole (14 and 4.0%; respectively). Other methods un-defined were reported by 0.9% of the participants. More than half (64.3%) of the participants reported not having waste disposal services. Of the respondents sampled, only 2.7% had attended post-college education, with 10.7, 25.9 and 35.7% having attended college, secondary and primary education respectively. A proportion of 17.4% had not attended any formal education at all.

A survey of the presence of household items that were used to characterize wealth revealed that the items owned by more than half of the participants included bed with mattress (80.8%), paraffin stove, radio and television (66.1, 65.6, and 61.2%; respectively). Many of the other household items in the questionnaire, including gas stove, microwave, hot plate, refrigerator, freezer, coal stove, lounge suite and dining suite were lacking among most of the participants (91.1, 86.6, 73.7, 63.8, 80.8, 75.4, 75.0 and 73.2%; respectively).

In general, the mean iron intake of the study group was 10.88 mg/day (13.51 ± 10.20 g/day and 10.31 ± 7.22 g/day for men and women respectively), which was above the Dietary reference intakes (DRIs) for men and women of South Africa (7.7 and 8.1 mg/day) respectively. In all forms (total, haem and non-haem iron intake), intake among men was higher than that of women (Table 2). Of the participants in the study, 84/224 (37.5%) consumed below the Estimated Average Requirement (EAR) for the group, and within sex groups more women (73/184; 39.7%) than men (11/40; 27.5%) consumed less than their respective EARs. Disaggregated by age, more men above 19 years of age (40.9%) and women below 50 years of age (43.8%) consumed less than their respective EARs compared with their counterparts below 19 and above 50 years of age for men and women; respectively (Table 3). Haem iron intake in the group was generally low; much less among women than men. The contributions of haem and non-haem iron to the total iron intake were 4.87% and 29.87% respectively. Food intake data (Table 2) indicated that few iron-rich foods were consumed by the participants.

Analysis by age group using confidence intervals (Table 3) revealed that there was no significant difference in total intake between the different age groups, although, intake of younger age groups for both men and women, looked higher than those of older participants.

All the average values of the haematological parameters were within acceptable levels, that is, above respective cut-off points (Table 4). However, depending on the parameter, the proportion of subjects with low measures of iron status was between 6.3 and 89.3% (2.2 and 17.1% for men; 4.0 and 72.3% for women) (Table 4).

Overall, more women had lower measures of iron status than did the men (Table 4). Results indicated that 18.8% of the individuals in the group had low concentrations of serum iron, a greater proportion (16.1%) of who were women. Most (89.3%) had low concentrations of TFR, the majority (72.3%) being women. Out of the 34.8% who had low ferritin levels, the greater proportion (29.9%) was women, compared with only 4.9% of men. Similarly, haemoglobin status, haematocrit and MCV measures indicated that more women were affected than men.

Overall, men of the younger age group (below 19 years) had a higher prevalence of low biochemical measures of iron than their older counterparts, except for TFR (Table 5). In particular, among younger men, 28% had a low percentage saturation of serum iron, 33% had low serum ferritin and haemoglobin levels respectively, 28% had low haematocrit, and 22% had low MCV. The ages of two women participants were not captured and therefore not included in the analysis. Although, similar trends were observed for the women, there was less discrepancy in the proportion of younger and older women who had low iron status. Among younger women, 21% had low serum iron, 89% had low TFR, with 12% having low Hb and HCT respectively. Serum ferritin levels were similar for the two age groups while women in the older group had lower MCV levels than the women in the younger age group.

A logistic regression between total iron intake, wealth and education revealed a significant association with wealth only ($p < 0.05$), but not with education (Table 6). Going by sex grouping, there were inconsistent observations, with significance observed only among women. Among men, the association between iron intake and household asset index was negative (OR = 0.750, CI 0.168 - 3.351), but the association with education was consistently positive for both combined data and data disaggregated by sex; although, not statistically significant (all Odds Ratios >1.0).

Table 7 shows associations between biochemical markers of iron status (as dependent variables) and selected predictors. As a group, wealth/asset index was significantly positively associated with serum iron, haemoglobin status, HCT and MCV (all p values <0.05). Although, the association between wealth/asset index and ferritin status was not significant ($p > 0.05$), results indicated a positive association, in which case, a wealthy individual was more likely to have serum ferritin measure above the recommended cut-off point (OR = 1.444).The association with TFR was significant but negative (OR = 0.226), indicating that persons from households with a higher wealth index had a lower chance of having a TFR measure above cut-off. This finding calls for further investigation. When disaggregated by sex, asset index indicated similar findings among the women, where significant associations ($p < 0.05$) were observed with serum iron status, TFR, Hb, HCT and MCV. Although not significant, the association with ferritin was positive (OR > 1.0), indicating a higher likelihood of measuring above recommended levels. For men, household asset index did not significantly predict iron status (all p values > 0.05).

In conclusion, considering all variables of iron status, total iron intake was the strongest predictor of iron status (all p values <0.05). Similarly, although the association with TFR was statistically significant, the association was negative. This finding requires further investigation. Disaggregated by sex, similar findings were observed among women for all variables of iron status, whereas among men, the association was only significant with MCV ($p< 0.05$). Finally, education status did not show any significant association with iron status (all p values > 0.05), and the odds ratios similarly showed mixed findings (Table 7).

DISCUSSION

Socio-demographic characteristics of participants

Our findings indicated that a majority of the participants lived in poverty, as many resided in a non-permanent zinc/shack form of housing and lacked most of the items used in constructing the wealth index. The proportion found to live in this kind of housing was quite high (Table 1), relative to the national figures of 14.5% (Stats SA, 2006) that still live in informal settlements in South Africa. We however found that, most of the respondents had access to safe/ tap water, irrespective of whether it was within the house, outside the house or from the public/ neighbour's tap. A majority also used flush toilets, which was consistent with national data (Stats SA, 2006) that reports Gauteng as one of the provinces with the highest proportion of the population using flush toilets. However, waste management services were lacking in the majority of households.

Only a small proportion of the participants had post-secondary education (Table 1), with the highest number having primary education (either complete or incomplete), the majority of who were women. This may be explained by the fact that women are always marginalized in terms of education (Gemma et al., 2003). Lack of education is generally accepted as perpetuating inequality, oppression and discrimination, leading to underdevelopment of human resources (World Bank, 2003). Owing to difficulties in obtaining comprehensive data of household income and expenditure, particularly in health-related household surveys, this study explored the possibility of using the household asset index to evaluate its association with health conditions, particularly the iron status of the participants. Furthermore, experience from fieldwork also indicates that household income is usually under-reported, particularly in rich or better-off households (Falkingham and Namzie, 2001). Moreover, a conversion of household products into money terms is difficult and prone to measurement errors. In this study, this was avoided by the use of household asset index.

With regard to asset ownership, we noted that the assets owned by more than half of the participants were the basic ones, including a bed and mattress, paraffin stoves, radio and television. However, ownership of these items could not give us information on the quality of the items owned and the levels of absolute income to which they could be attached, in order to identify who was better off in this population. It is acknowledged that those better off usually have a much better quality of items than their poor counterparts may own (Moser, 1998), for example a colour television rather than black and white. This differentiation was not made in this study. Our finding supports other reports which have also indicated increased numbers of South Africans owning such items as television sets and radio (Stats SA, 2006). Most of the households, however, lacked some of the household items that characterize higher socio-economic position and that were used in deriving the asset index for this study. Such items included a gas stove, microwave, hot plate, refrigerator, freezer, coal stove, a lounge suite and a dining suite.

However, there are assets with high scoring factors such as a washing machine, a telephone, a video recorder, a VCD/ DVD player and palm computer, which are also related to new technologies, but were not included in this study. These assets tend to play a major role in the construction of a wealth index, and because of their high power of socio-economic differentiation, we recommend that such items should be included in future studies of asset ownership.

Dietary iron intake and association with biochemical iron measures

Generally, the mean iron intake of the group was higher than the dietary reference intake for both men and women, suggesting a low risk of deficiency in this study group. The contributions of haem and non-haem iron to the total iron intake were low (Tables 2 and 3). This suggests that there was either under-reporting of food intake which created a large discrepancy between the observed daily iron intake of 39.16 (g)/day, haem and non-haem iron intakes, or that; there may have been other non-prescribed sources of iron intake in the diet of the participants that were not listed in the data base. Because of the detailed nature of dietary recording, misreporting is a potential problem in all such surveys, and could have an impact on the recorded intake of all dietary constituents, resulting in an underestimation of intakes. However, misreporting is unlikely to affect the validity of our conclusions adversely because estimation of iron intake was used merely to classify those who consumed less than the recommended levels. The low bioavailability of iron in some iron-containing foods cannot be ignored, which may also have caused this discrepancy. Indeed, dietary consumption data revealed a high intake of plant sources, for example maize meal (stiff as well as porridge), together with a low intake of haem iron sources such as meat, fish and chicken. The availability of iron from the non-haem foods could also be decreased by the high intake of tea and coffee (Table 2), which were among the top 20 foods consumed by the participants.

Age and gender have been shown as factors influencing iron status (Lesourd et al., 1996; Finch et al., 1998), and two age groups were therefore analyzed to examine the relative effects of other explanatory factors within these age groups. Different age groups were considered for different sexes, considering the fact that recommendations of iron intake differ with age for each gender (CDC, 2008). When disaggregated by gender, findings revealed that for all forms of iron intake (total, haem and non-haem) the mean daily iron intake of men was relatively higher than the intake of women. These results are comparable to findings by other researchers Doyle et al. (1999), Gibson and Ashwell (2003), who reported a higher daily iron intake among men than

Table 1. Socio-economic characteristics of the participants. The number of respondents is different for different socio-economic variables.

Item	Frequency (n)	Proportion (%)
Gender (n=224)		
Men	40	17.9
Women	184	82.1
Age category (n=222)		
<19 years	53	23.7
19-50 years	136	60.7
> 50 years	33	14.7
Number of people in the household (218)		
1-5 people	124	55.4
6-10 people	82	36.6
More than 10 people	12	5.4
Type of house (n=210)		
Brick	54	24.1
Clay	5	2.2
Grass	1	0.4
Zinc/ Shack	149	66.5
Other (unspecified)	1	0.4
Number of rooms in the house (n=189)		
< 2 rooms	52	23.2
3-4rooms	86	38.4
> 4 rooms	51	22.8

Table 1 Contd.

Water source (n=216)		
Tap in the house	21	9.4
Tap in yard (outside house)	172	76.8
Borehole	1	0.4
Spring/river/dam water	3	1.3
Fetch water from elsewhere	19	8.5
Toilet facility (n=212)		
No toilet facility	10	4.5
Pit latrine	29	12.9
Flush/ sewerage	157	70.1
Bucket system	14	6.3
Hole	4	1.8
Other	2	0.9
Waste Disposal service (n=198)		
Yes	54	24.1
No	144	64.3
Educational level (n=207)		
None	39	17.4
Primary school	80	35.7
Secondary school	58	25.9
College	24	10.7

Table 1. Contnd.

Other post-college	6	2.7
Presence of household items		
Electrical stove (n=224)		
Yes	80	35.7
No	144	64.3
Gas stove (n=224)		
Yes	20	8.9
No	204	91.1
Paraffin stove (n=224)		
Yes	148	66.1
No	76	33.9
Microwave (n=224)		
Yes	29	13.4
No	195	86.6
Hotplate (n=224)		
Yes	59	26.3
No	165	73.7
Radio (n=224)		
Yes	147	65.6
No	77	34.4

Table 1 Contd.

TV (n=224)			
	Yes	137	61.2
	No	87	38.8
Refrigerator (n=224)			
	Yes	81	36.2
	No	143	63.8
Freezer (n=224)			
	Yes	43	19.2
	No	180	80.8
Bed and mattress (n=224)			
	Yes	181	80.8
	No	43	19.2
Lounge suite (n=224)			
	Yes	55	24.6
	No	169	75.4
Dining room (n=224)			
	Yes	56	25.0
	No	168	75.0
Coal stove (n=224)			
	Yes	60	26.8
	No	164	73.2

Table 2. Mean daily iron intake (mg) for men and women in the study group, as measured by 24 h recall, together with Top 20 food items consumed by the group (n=224). The foods are presented in their order of importance.

	24 h recall data		
	Mean	**SD**	**Below EAR (%)**
Combined (n = 224)			
Total Iron	10.88	7.91	
Haem iron	0.53	0.77	37.5
Non-haem iron	3.25	3.03	
Men (n = 40)			
Total Iron	13.51	10.20	
Haem iron	0.85	1.16	27.5
Non-haem iron	4.62	4.42	
Women (n = 184)			
Total iron	10.31	7.22	
Haem iron	0.46	0.64	39.7
Non-haem iron	2.95	2.56	

Top 20 food items as measured by QFFQ	
Food items	**Mean daily intake (grams per person)**
Water	450.0
Maize meal	400.6
Cold drink (carbonated)	317.5
Maize meal(soft porridge)	264.0
Tea (Rooibos)	250.0
Orange	180.0
Egg	169.0
Rice	156.0
Milk	151.0
Beef	150.0
Sorghum porridge	144.4
Mango (raw, peeled)	130.6
Bread	120.1
Coffee brewed	118.0
Tomato/Onion gravy	105.0
Orange (raw, peeled)	102.0
Cold drink (Squash)	100.5
Tea, brewed	98.12
Macaroni/Spaghetti	92.6
Sausage	90.0

women. Reasons for higher intake among men may be associated with their high food intake. However, dietary iron intake should be assessed with caution. Although, total intake was above dietary reference intakes, it is important to distinguish the proportion of total iron obtained from animal food sources. In this study, as pointed out, while approximately 61.6% of the subjects had a total iron intake greater than is recommended (that is, 138 participants), only a small proportion of this intake was from animal/haem iron, while a greater proportion was from non-haem iron. Thus, individuals with similar iron intake may well differ in the extent to which they may be at risk of anaemia and iron deficiency. Owing to the limited nature of the data in the public domain in this survey, our estimate could not adjust for the effects of components that enhance or inhibit iron absorption within meals, although it did account for two prime influences: the form of iron (haem and non-haem) and the iron status of the participants.

In most of the biochemical measures of iron intake, fewer men than women had low biochemical measures of iron, suggesting inequality in the population. Of those with low measures (Table 4), lower proportions (for all respective biochemical measures) were men, which may be explained either by the higher intake recorded among men (Table 2) or by the fact that women lose iron monthly through menstruation, which depletes their iron stores. Anaemia (defined as Hb<13g/dl and <12g/dl for men and women respectively) was comparable to the rates reported by Charlton et al. (1997) for community-dwelling South Africans. This is higher than that reported in other studies in Europe and the United States of America. Causes of such high levels range from inadequacies in dietary intake to chronic disease infections.

Using ferritin levels as indicators of iron deficiency, findings indicated that iron deficiency is prevalent in this population, particularly among women (Table 4). Hyper-ferritinaemia has often been reported as more common than low iron stores in older South Africans, especially among men (Charlton et al., 1997; Charlton et al., 2005). This may also explain the low rates of deficiency found among men in comparison with the women in this study. However, ferritin is an acute-phase protein and is typically elevated in cases of infection, inflammation and malignancy, which were not considered in this study. Disaggregated by age, findings were inconsistent in that among men, the older age group (above 19 years) was highly affected, while among women, the younger age group (less than 50 years) was highly affected.

Results of association between daily iron intake and asset index and education for the combined group showed a significant positive association with asset index

Table 3. Average daily intake (mg) of total, haem and non-haem iron from food disaggregated by age and gender, and proportions below estimated average requirement based on the South African guidelines (n = 222).

Variables	Combined mean (SD)	Men mean (SD), (95%CI)		Women[§] mean (SD), (95%CI)	
From food		<19yrs[a.](n=18)	19+ yrs[b.](n=22)	<50yrs[c.](n=146)	50+ yrs[d.](n=36)
Total iron (mg)	10.88 (7.91)	17.37 (12.04)(12.68-23.33]	10.34 (7.26)(7.16-13.48)	10.82 (7.74)(9.38-12.14)	8.07 (4.14)(6.73-9.51)
Haem iron (mg)	0.53 (0.77)	1.03 (1.24)(0.48-1.58)	0.70 (1.10)(0.33-1.26)	0.50 (0.68)(0.40-0.63)	0.30 (0.41)(0.19-0.45)
Non—haem iron (mg)	3.25 (3.03)	5.81 (5.31)(3.71-8.14)	3.64 (3.36)(2.40-5.08)	3.11 (2.65)(2.70-3.61)	2.17 (2.03)(1.58-2.83)
% below EAR		2/18 (11.1)	9/22 (40.9)	64/146 (43.8)	9/36 (25.0)

a. EAR = 7.7 mg/day; b) EAR = 6.0 mg/day; c) Ear = 8.1 mg/day; d) EAR = 5.0 mg/day; Dietary Reference Intakes adapted from NICUS (2003). [§]. Age for two women respondents was not captured and thus not included in the above results.

($p < 0.05$), and a positive but not significant association with education. At the level of gender, however, mixed findings were observed, where a significant positive association was seen among women but a negative association among men.

The association with education was consistently positive in all gender groups, corroborating some findings (Djazayeri et al., 2001), but not agreeing with others (Agho et al., 2008). However, the non-significance in association with education could be due to the smaller numbers used in the study. A look at associations between biochemical measures and their predictors (household asset index, education and total iron intake), revealed that asset index and iron intake were significant predictors that could explain differences in iron status in this population. Except for TFR, associations with all other biochemical variables were positive. This relationship corroborates findings by others (Sahn and Stifel, 2003; Rahman and Nasrin, 2009) that asset index is generally a valid predictor of nutritional status.

As expected, total iron intake was significantly positively associated with biochemical markers of iron intake, predicting iron status best among women. Although some of the fixed factors known to influence iron status, such as vitamin C, folate and vitamin B_{12} intake (Péneau et al., 2008); calcium, infection and inflammation (Fitch, 2007); and levels of energy intake were not controlled for in the analysis, the results have nevertheless been able to show strong associations with iron status. The lack of significant associations among the men could be explained in terms of numbers (n = 40) that participated in the study. The findings on the association between education and biochemical indicators were not in agreement with other people's findings (Wamani et al., 2004), and this calls for further investigation.

LIMITATIONS

Our study had some limitations. In a cross-sectional study like this one, it is impossible to say anything about relationships of cause and effect. Secondly, studying iron status among different gender groupings is quite challenging. Different gender groups have different recommendations for daily iron intake, which poses challenges in the presentation of results because different recommendations exist for different age groups within gender groups.

Thirdly, some of the respondents had missing data on some questions on socio-economic status, making it very difficult to measure their status against that of others. In the future, it is recommended that a study like this should focus on only one gender group in order to convey a true representation of the situation. Nonetheless, considering that the objective was to examine predictors of inequality, particularly in iron status, this study has policy implications.

The household items used in the study to derive asset index were assumed to represent distinct dimensions of different domains of wealth in this informal settlement, although, they say nothing about levels of absolute income.

It created an opportunity to compare household living standards over time with reference to longer-term or permanent income. While the population group reported here may not be entirely representative of the whole population of Gauteng, it has offered an opportunity to look at the relationship between household welfare, iron intake and different measures of iron status.

In interpreting the correlations between measures of iron status and iron intake, it should be remembered that the blood samples were taken during the period in which the socio-economic data and dietary record were completed.

Table 4. Mean biochemical measures of iron intake for the group and disaggregated by gender (n=224). Data are presented as means, with standard deviations in parentheses; low measures of iron status and total prevalence in italics.

Biochemical measures					Prevalence (%)		
Biomarker (units)	**Cut-off points§**	**Combined mean, (SD)**	**Men mean, (SD)**	**Women mean, (SD)**	**Men N (%)**	**Women N (%)**	**Total (%)**
Serum Iron (µmol/L)	<13.0 (Both sexes)	24.60 (17.37)	21.16 (12.83)	25.35 (18.15)	6 (2.7)	36 (16.1)	18.8
Transferrin receptor (TFR) (mg/L)	4 (Both sexes)	3.12 (0.64)	3.00 (0.55)	3.15 (0.66)	38 (17.1)	162 (72.3)	89.3
Ferritin µg/L	20 (Both sexes)	27.68 (15.26)	26.10 (11.94)	28.03 (15.90)	11 (4.9)	67 (29.9)	34.8
Haemoglobin g/dl	<13.0 Men <12.0 women	13.51 (1.53)	14.16 (1.95)	13.38 (1.39)	10 (4.5)	18 (8.0)	12.5
Haematocrit (HCT)	39 Men 36 women	40.36 (4.19)	41.95 (5.56)	40.02 (3.76)	13 (5.8)	18 (8.0)	13.8
Mean corpuscular volume (MCV)	<80 fl (Both sexes)	85.44 (4.25)	85.37 (4.02)	85.45 (4.31)	5 (2.2)	9 (4.0)	6.3

§. Cut-off points adopted from CDC (2008).

Table 5. Proportion of individuals with low measures of iron status (as measured by respective indices) with age (n = 222).

Biomarker (units)	**Men**		**Women**	
Serum biomarkers	<19 years§ (n=18) [CI]	19+ years§ (n=22) [CI]	<50 years§(n=146) [CI]	50+ years§ (n=36) [CI]
Serum Iron	5/18 (27.8)(11.0-51.3)	1/22 (4.5)(0.2-20.4)	666130/146 (20.5)(14.6-27.7)	5/36(13.9)(5.3-28.1)
Transferrin receptor (TFR)	17/18 (94.4)(75.5-99.7)	21/22 (95.5)(79.6-99.8)	130/146 (89.0)(83.2-93.4)	31/36 (86.1)(71.9-94.7)
Ferritin	6/18 (33.3)(14.8-56.9)	5/22 (22.7)(8.8-43.4)	53/146 (36.3)(28.8-44.3)	13/36 (36.1)(21.8-52.6)
Haemoglobin	6/18 (33.3)(14.8-56.9)	4/22 (18.2)(6.1-38.2)	17/146 (11.6)(7.2-17.6)	1/36 (2.8)(0.1-13.0)
Haematocrit (HCT)	6/18 (33.3)(14.8-56.9)	7/22 (31.8)(15.1-53.1)	17/146 (11.6)(7.2-17.6)	1/36 (2.8)(0.1-13.0)
Mean corpuscular volume (MCV)	4/18 (22.2)(7.5-45.3)	1/22 (4.5)(0.2-20.4)	7/146 (4.8)(2.1-9.3)	2/36 (5.6)(0.9-17.2)

§. Different age groups have been used for different sexes owing to variations in EAR for age for each sex.

Table 6. Logistic regression model between total iron intake with wealth and education, among the participants (n=224).

Variable	Exp (B)	Sig (2-tailed)	95% Confidence interval	
			Lower	Upper
Combined [a.]				
Household asset index	2.091	0.044	1.019	4.289
Education	4.000	0.215	0.447	35.788
Men [b.]				
Household asset index	0.750	0.706	0.168	3.351
Education	2.000	0.571	0.181	22.056
Women [c.]				
Wealth asset index	2.857	0.017	1.208	6.757
Education	1.615E9	0.999	0.000	.

a. Results based on 224 samples, b) Results based on 40 samples, c) Results based on 184 samples, d) Dependent variable: Total iron intake (0=below recommended intake, 1= above recommended intake).

Conclusion

The results of the present study have provided baseline information on socio-economic and other factors potentially influencing iron status. For the demographic and nutritional data obtained for this population, we conclude that household asset index, (a proxy measure of socio-economic status) together with the level of iron intake, butnot educational level, explains iron inequality in a black population in Gauteng region, South Africa. Any programme aimed at long-term improvement in the nutritional status of populations in South Africa (particularly in reducing the prevalence of iron deficiency) will require a strategy to improve household welfare by either increasing job opportunities or providing grants to the poor households. Such a strategy should receive particular attention in national economic planning.

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Table 7. Logistic regression between biochemical markers of iron intake and their predictors.

Dependent variable	Predictors	Combined (n=244)		Men (n=40)		Women (n=184)	
		EXP (B)	P	EXP (B)	P	EXP (B)	P
Serum iron [a]	Wealth/asset index	3.600	0.022*	1.118E8	0.999	2.945	0.057†
	Educational level	0.533	0.515	1.045	0.973	0.448	0.601
	Total iron intake	3.694	0.000***	2.787	0.057†	4.975	0.000***
TFR [a]	Wealth/asset index	0.226	0.019*	0.000	0.999	0.265	0.038*
	Educational level	0.000	0.999	0.000	0.999	0.000	0.999
	Total iron intake	0.195	0.000***	0.063	0.007**	0.126	0.000***
Ferritin [a]	Wealth/asset index	1.444	0.353	1.325E9	0.999	1.077	0.856
	Educational level	0.959	0.964	1.444	0.773	0.759	0.847
	Total iron intake	1.758	0.011*	1.652	0.306	1.737	0.007**
Haemoglobin [a]	Wealth/asset index	4.516	0.017*	1.149E9	0.999	3.697	0.042*
	Educational level	0.429	0.391	0.259	0.302	7.692E8	0.999
	Total iron intake	4.842	0.000***	2.546	0.078†	8.838	0.000***
HCT [a]	Wealth/asset index	4.516	0.017*	4.252	0.189	5.990	0.018*
	Educational level	0.429	0.391	0.246	0.285	7.730E8	0.999

Table 7 Contd.

	Total iron intake	4.842	0.000***	2.725	0.057†	8.674	0.000***
MCV [a]	Wealth/asset index	3.700	0.041*	3.385	0.280	5.478	0.026†
	Educational level	0.845	0.894	0.506	0.645	6.917E8	0.999
	Total iron intake	9.150	0.000***	9.786	0.004**	18.372	0.000***

[a]. Dependent variables. 0= below recommended cut-off point, 1= above recommended cut-off point. †. Significant at p<0.1; *. P < 0.05; **. p<0.01; ***. P < 0.001.

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