

Received:

5 July 2018

Revised:

30 October 2018

Accepted:

26 November 2018

Cite as:

Reinette Tydeman-Edwards,
Francois Cornel Van Rooyen,
Corinna May Walsh. Obesity,
undernutrition and the double
burden of malnutrition in the
urban and rural southern Free
State, South Africa.

Heliyon 4 (2018) e00983.

doi: [10.1016/j.heliyon.2018.](https://doi.org/10.1016/j.heliyon.2018.e00983)

e00983



Obesity, undernutrition and the double burden of malnutrition in the urban and rural southern Free State, South Africa

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Abstract

This study compared the diet and anthropometric status of adults (25–64 years) in rural and urban South Africa. Anthropometric status of adults and preschool children (<7 years old) from the same households were also determined.

A descriptive cross-sectional design was applied. All adults from three towns in the rural southern Free State (n = 553) and a stratified proportional cluster sample from urban Mangaung (n = 419) participated. Anthropometric assessments included body mass index and waist circumference. Trained students administered a qualitative food frequency questionnaire in a structured interview with each participant to assess frequency of consumption of foods. The 35 foods that were included were chosen as a measure of protection or predisposition to obesity and non-communicable diseases. The height-for-age, weight-for-age and weight-for-height of 60 rural and 116 urban children were also assessed.

Sugar was the most frequently consumed food item, eaten at least twice per day by all groups. Cooked porridge was the most frequently consumed starchy food (range 47.3–53.2 times a month), followed by bread, consumed at a mean frequency of 20 or more times per month in all groups. Tea was the most frequently consumed fluid

(used at least once a day by all). Salt and/or stock was used more than once a day, while margarine, oil and other fats were consumed at least once per day. Fruit and vegetables were consumed at a mean frequency of less than once a day, while milk was consumed less than once daily in urban participants and once per day in rural participants. Chicken or eggs were the most frequently consumed protein-rich food (approximately 10 times per month). Overweight/obesity was identified in 65.6% rural and 66.2% urban women. Fewer men (23.3% rural and 16.0% urban) were overweight/obese. More than 66% of stunted, underweight and wasted children lived with an overweight/obese caregiver.

Daily consumption of sugar, salt and fats and inadequate frequency of consumption of vegetables, fruits and milk was confirmed in both rural and urban participants. In addition, a double burden of malnutrition was evident.

Keywords: Nutrition, Public health

1. Introduction

According to the World Health Organization (WHO), the dietary and individual risk behaviour of people fundamentally define their health, growth and development [1]. A large percentage of South Africans live in poverty, which predisposes them to food insecurity, malnutrition and disease. A vicious cycle ensues, with poor living conditions and a high prevalence of infectious diseases contributing to malnutrition [2]. Historically, food poverty has been associated with rural communities in South Africa [3, 4], however, more recently, urbanisation has resulted in a marked shift in poverty from rural to urban areas in the country [5].

In addition to infectious diseases and undernutrition, obesity-related non communicable diseases (NCDs), such as cardiovascular disease, diabetes mellitus (DM), and stroke, are reaching epidemic proportions in developing countries [2]. In South Africa, NCDs often co-exist with poverty-related infectious diseases and malnutrition [6]. The nutrition transition is characterised by a shift from traditional diets towards a more westernised diet. Although lower in variety, traditional diets tend to be higher in fibre and lower in fat, sugar and salt [7], resulting in a low prevalence of NCDs, whereas the Western diet is associated with an increased risk for developing NCDs [6].

According to the WHO [1], “it is not surprising that food insecurity and undernutrition persist in the same countries where chronic diseases are emerging as a major epidemic”. Results from the South African National Health and Nutrition Examination Survey (SANHANES-1) showed that the prevalence of stunting [weight-for-age below -2 standard deviations from the WHO median] in children younger than 15 years in the Free State Province, was 19.4% in boys and 22.1% in girls [8]. Stunted children have a higher risk of becoming overweight or obese, thereby increasing the

risk for NCDs in adulthood, a condition termed the double burden of malnutrition [2, 9, 10]. Low birth weight and small size during infancy, followed by rapid weight gain in childhood, are predictive of NCDs [11], specifically hypertension, coronary heart disease and type 2 DM [12].

In an effort to promote health and quality of life, it is of the utmost importance to limit this burden of disease in South Africa by understanding the contribution of lifestyle to obesity and its comorbidities. With this in mind, the Assuring Health for All in the Free State province of South Africa (AHA FS) study aimed to determine how living in both rural and urban areas predisposes or protects people from developing disease. The aim of this sub-study was to gain insight into the frequency of consumption of foods and anthropometry of adults aged 25–64 years in the rural and urban Free State Province. Secondly, we determined the association between anthropometry of adults and children living in the same household in order to identify whether a double burden of malnutrition was present and to provide insights for relevant interventions.

2. Methods

2.1. Population and sampling

The AHA FS baseline study was undertaken in the Free State Province in rural areas in 2007 and urban areas in 2009. All households in the townships of rural Trompsburg, Philippolis and Springfontein were eligible to participate. In urban Mangaung, the number of plots in the Mangaung University Community Partnership Programme (MUCPP) service area was counted on a municipal map and included Buffer, Freedom Square, Kagisanong, Chris Hani, Namibia and Turflaagte. An estimate was made of additional squatter households in open areas. A stratified proportional cluster sample was selected, stratified by area and formal plot/squatter households in open areas. Using randomly selected X and Y coordinates, 100 starting points were selected. From each starting point, five adjacent starting households were approached. A total of 499 and 387 households were included from rural and urban areas, respectively. A total of 553 and 419 adults (25–64 years) and 60 and 116 children (<7 years old) were assessed in these rural and urban households, respectively.

2.2. Ethical considerations

Approval to conduct the study was obtained from the Ethics Committee of the Faculty of Health Sciences at the University of the Free State (ETOVS NR 21/07A), Free State Department of Health, local municipalities and community leaders. Written informed consent or assent was obtained from all participants. All the participants' information was treated confidentially.

2.3. Techniques and data collection procedures

A cross-sectional descriptive study was undertaken. Communities were informed about the project through community information sessions. Trained fieldworkers from each community visited each household (in some cases on more than one occasion), explained the purpose of the study, and encouraged all eligible volunteers between 25 and 64 years of age to participate. Written informed consent was obtained from all participants in their language of choice. Prior to the main study, pilot studies were undertaken in both rural and urban areas. In each area, five persons that were similar to the target group, were included in the pilot, in order to determine whether questions included in the questionnaires could be easily understood and to determine the amount of time needed to collect data.

On days of data collection, participants arrived at the research venue (community halls in rural areas and the MUCPP nutrition centre in the urban area) in a fasting state. The identity document of each respondent was screened to ensure that participants met the inclusion criteria for age. Stations included points for collection of blood and urine samples; a food station; medical examination; and anthropometric measurements. Thereafter, questionnaires related to the following aspects were completed: sociodemography; household food security; diet; physical activity; reported health; and knowledge, attitudes and practices related to nutrition. Results obtained from these assessments have been reported elsewhere [13, 14, 15].

Dietary intake data was collected by trained students using a qualitative food frequency questionnaire (FFQ) completed in a structured interview with each participant. Sesotho, Setswana and isiXhosa interpreters assisted the researchers where necessary. The qualitative FFQ was developed for the current study with the aim of determining habitual intake of 35 specific foods. The foods that were included in the questionnaire were chosen as a measure of protection or predisposition to obesity and non-communicable diseases. Foods were grouped into logical food groups including starchy foods; liquids; foods with a high fat content; foods with a high sugar content; foods with a high salt content; fruits and vegetables; and protein-rich foods. Participants were asked how frequently they ate the food per day, per week and per month and this was used to calculate frequency of consumption per month. In order to determine reliability of data, the FFQ was administered again to 10% of the original sample one week after the initial assessment. Where responses related to frequency of consumption between the two assessments differed by more than 20%, the data was considered to be unreliable. No responses were found to be unreliable.

In adults anthropometric variables included body-mass index (BMI) in kg/m^2 and waist circumference (WC) in cm, while height-for-age, weight-for-age and weight-for-height were determined in children. All measurements were taken using

standardized techniques and calibrated instruments. The measurements were done by trained dietetics students according to the standards of the International Society for the Advancement of Kinanthropometry. Measurements were taken in duplicate with participants wearing an examination gown, without shoes. Height was measured with a stadiometer to the nearest 0.5 cm and weight with a digital scale to the nearest 0.1 kg. Waist circumference was measured with a flexible, non-elastic tape measure to the nearest 0.5 cm, horizontally midway between the inferior margin of the ribs and the superior border of the iliac crest. Adults were categorised as underweight [BMI less than 18.5 kg/meter square (kg/m^2)]; normal weight (BMI 18.5 kg/m^2 or over, but less than 25 kg/m^2); overweight (BMI 25 kg/m^2 or over, but less than 30 kg/m^2); or obese (BMI 30 kg/m^2 or over). A WC equal to or larger than 94 cm for men and 80 cm for women was considered as a high risk WC. In children, measurements below -2SD from the WHO reference median were indicative of underweight (weight-for-age), stunting (height-for-age) and wasting (weight-for-height).

2.4. Statistical analysis

Descriptive statistics included frequencies and percentages for categorical data, and means and standard deviations (SD) for continuous data. Differences between urban and rural data were assessed with 95% confidence intervals (CI) or p-values (<0.05 being regarded as statistically significant). For differences in means the student t-test was applied, while for categorical data chi-square and Fisher Exact tests were used. Associations between the anthropometric status of adults and children were determined using 2×2 tables. Data were analysed by the Department of Biostatistics at the University of the Free State in Bloemfontein, South Africa.

3. Results

3.1. Age

Rural women were significantly older than urban women at 47.1 years (SD 10.4) and 44.3 years (SD 10.5) respectively ($p = 0.004$). Rural and urban men had a mean age of 48.1 (SD 10.2) and 45.2 years respectively ($p = 0.19$) (SD 10.8).

3.2. Dietary intake

Table 1 summarises the intake of foods according to the frequency of consumption per month by rural and urban men and women (mean number of times consumed per month). Sugar was the most frequently consumed food item with a mean frequency of 60 times per month by all groups, thus at least twice per day. Cooked porridge was the most frequently consumed starchy food (range 47.3–53.2 times a month),

Table 1. Mean frequency of the consumption of different food types per month.

Type of food consumed	Men				Women			
	Rural (n = 161)		Urban (n = 99)		Rural (n = 389)		Urban (n = 320)	
	Mean	SD ^a	Mean	SD	Mean	SD	Mean	SD
Starchy foods								
Porridge, cooked	53.2	26.2	49.4	26.6	49.8	26.6	47.3	26.4
Bread	22.6	21.7	20.0	24.4	26.6	24.8	28.0	26.7
Samp/mealie rice	6.2	6.8	7.0	9.4	6.6	7.1	5.2	7.3
Cereal	3.7	7.1	7.9	14.1	7.8	13.1	8.3	12.1
Liquids/fluids								
Tea	37.3	42.8	42.7	36.0	44.1	34.9	53.8	41.7
Full cream milk	36.8	33.1	23.8	27.2	32.4	30.7	25.2	26.4
Coffee	29.9	34.8	27.5	31.5	20.2	26.9	18.7	28.3
Cooldrinks	19.3	29.5	12.0	17.6	20.0	28.3	13.7	19.3
Alcohol	9.1	27.6	10.9	29.2	3.9	14.9	1.4	3.2
Fruit juice	8.4	16.9	6.9	12.8	8.7	16.1	8.2	13.4
Low fat/skim milk	1.5	11.0	1.6	12.2	1.4	7.5	1.4	8.2
High fat content								
Margarine/oil/fat	26.7	25.0	25.7	22.5	36.5	29.5	34.7	24.1
Coffee creamer (Cremora)	26.7	36.5	12.5	21.8	22.8	31.2	12.9	25.9
Peanut butter/peanuts	6.5	13.0	7.9	10.8	6.6	12.1	8.0	11.2
Chips/crisps	9.4	13.2	7.2	9.7	10.2	15.4	8.6	11.3
High sugar content								
Sugar	62.0	43.7	63.6	44.2	66.4	43.8	73.0	51.2
Cake/biscuits	14.2	27.8	14.2	60.8	19.8	35.4	8.4	13.3
Sweets/chocolates	8.8	18.0	6.1	9.3	11.6	24.5	10.2	17.7
High salt content								
Salt/stock	42.6	32.0	36.7	23.7	43.9	32.3	38.7	25.6
Fruit and vegetables								
Fruit	26.3	34.3	17.8	20.1	28.4	32.6	19.5	23.5
Vegetables	17.2	16.1	19.9	20.2	18.7	17.4	21.5	19.4
Protein rich foods								
Chicken	10.4	9.8	8.4	7.3	12.2	13.3	9.8	10.7
Eggs	10.5	16.9	10.5	15.2	9.0	13.0	9.0	11.6
Fish	6.8	7.6	4.5	7.7	6.0	9.3	3.9	6.7
Soy mince/legumes	6.8	7.2	9.0	12.7	8.5	9.0	7.7	9.7
Red meat	6.6	6.9	4.7	5.6	5.7	7.6	3.9	4.7

^aSD = standard deviation.

followed by bread, consumed at a mean frequency of 20 or more times per month in all the groups.

Tea was the most frequently consumed fluid (used at least once a day by all), followed by full cream milk, coffee and sugar-sweetened cool-drinks. Urban men consumed alcohol most frequently (about 10 times per month). In rural areas, coffee creamers were used more frequently by both men and women than in urban areas.

Food with a high fat content, such as brick margarine and sunflower oil, were used less frequently by men than women, the latter consuming these foods at a mean frequency of at least once per day. Women also tended to eat sweets and chocolates slightly more often than men. Although rural participants consumed fruit more frequently than urban participants, fruit and vegetables were consumed at a mean frequency of less than once a day by all groups. In rural areas milk was consumed more frequently than in urban areas (at a mean of once per day) by both men and women, while in urban areas milk was consumed at a frequency of less than once per day.

Chicken or eggs were the most frequently eaten protein-rich foods, consumed by all groups at a mean frequency of approximately 10 times per month. Soy mince or legumes, red meat, peanut butter and fish were consumed by all groups at a mean frequency of less than 10 times a month.

3.3. Anthropometry: adults

The distribution of the participants per BMI category is shown in Table 2. The mean BMI for men was in the normal category (rural: 20.4 kg/m²; urban: 20.3 kg/m²), while the women's mean BMI was in the overweight category (rural: 28.2 kg/m²; urban: 28.3 kg/m²). Approximately two thirds of female participants (65.6% rural and 66.2% urban) were overweight or obese (Table 2). Although fewer men were

Table 2. Distribution of participants with regard to body mass index (BMI).

BMI categories [16]	Men (%)			Women (%)		
	Rural (n = 163)	Urban (n = 100)	p-value	Rural (n = 390)	Urban (n = 319)	p-value
	n (%)	n (%)		n (%)	n (%)	
<18.5 kg/m ² : underweight	54 (33.1)	23 (23.0)	0.09	36 (9.2)	28 (8.8)	0.9
18.5–24.9 kg/m ² : normal	71 (43.6)	61 (61.0)	0.007 ^a	98 (25.1)	80 (25.1)	0.9
25–29.9 kg/m ² : overweight	25 (15.3)	12 (12.0)	0.5	87 (22.3)	80 (25.1)	0.4
≥30 kg/m ² : obese	13 (8.0)	4 (4.0)	0.2	169 (43.3)	131 (41.1)	0.6
Mean BMI (kg/m ²)	20.4	20.3		28.2	28.3	

^aStatistically significant.

overweight or obese (23.3% rural; 16% urban), a significantly larger percentage of urban than rural men (urban: 61.0%; rural: 43.6%) had a normal BMI ($p = 0.007$). A third (33.1%) of rural men and 23% of urban men were underweight, but the difference was not statistically significant.

The distribution of participants per waist circumference (WC) category is shown in [Table 3](#). The mean WC for men was in the normal category (rural: 78.5 cm; urban: 76.0 cm), while the women's mean WC was in the "at risk" category for urban women (87 cm) and "high risk" category for rural women (92.0 cm). More than half of rural women (57.9%) and about half of urban women (48.6%) has a WC in the "high risk" category ([Table 3](#)). A significantly larger percentage of urban than rural men (urban: 94%; rural: 79.8%) had a normal WC ($p = 0.002$). For women, a significantly larger percentage of urban than rural women (urban: 32%; rural: 24.4%) had a normal WC ($p = 0.03$) and significantly more rural than urban women had a WC in the "high risk" category ($p = 0.02$).

3.4. Anthropometry: children

The mean age of rural girls was two and a half years, whereas it was three years for rural and urban boys and urban girls. The number of children included in the study was too small to report on the prevalence of malnutrition. However, as shown in [Table 4](#), approximately two thirds of stunted children in the rural areas (63.2%) and 71.8% in urban areas resided with an overweight/obese caregivers. Similarly, two thirds of both rural and urban underweight children and most of the wasted children (100% rural; 75.0% urban) lived with overweight or obese caregivers.

One third (33.0%) of both rural and urban underweight children resided with caregivers in the normal/underweight BMI category. It should be noted, however, that the children in this study were not assessed for overweight and obesity, and therefore

Table 3. Distribution of participants with regard to waist circumference categories.

Waist circumference categories [17]	Men			Women		
	Rural (n = 163)	Urban (n = 100)	p-value	Rural (n = 390)	Urban (n = 319)	p-value
	n (%)	n (%)		n (%)	n (%)	
Normal (male: <94 cm; female: <80 cm)	130 (79.8)	94 (94.0)	0.002 ^a	95 (24.4)	102 (32.0)	0.03 ^a
At risk (male: 94–101 cm; female: 80–87 cm)	17 (10.4)	2 (2.0)	0.01 ^a	69 (17.7)	62 (19.4)	0.6
High risk (male: ≥102 cm; female: ≥88 cm)	16 (9.8)	4 (4.0)	0.09	226 (57.9)	155 (48.6)	0.02 ^a
Mean (cm)	78.5	76.0		92.0	87.0	

^aStatistically significant.

Table 4. Distribution of children residing with normal/underweight and overweight/obese adult caregivers.

Adult caregivers' BMI category	Categories of malnutrition in children					
	<-2 SD stunted		<-2 SD underweight		<-2 SD wasted	
	Rural n=19	Urban n=39	Rural n=15	Urban n=15	Rural n=6	Urban n=8
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Underweight and normal weight (BMI <25 kg/m ²)	7 (36.8)	11 (28.2)	5 (33.3)	5 (33.3)	0 (0)	2 (25.0)
Overweight and obese (BMI ≥25 kg/m ²)	12 (63.2)	28 (71.8)	10 (66.7)	10 (67.7)	6 (100)	6 (75.0)

the distribution of overweight/obese children with regard to the BMI category of their caregivers could not be determined.

4. Discussion

The findings pertaining to frequency of food consumption of the AHA FS study were similar to studies conducted in other parts of South Africa [18]. Prudent dietary guidelines recommend a diet high in unrefined cereals, fruit and vegetables, and low in saturated and trans fats, salt and sugar [19]. As a Western eating pattern is adopted, a diet that is denser in energy, with fewer starchy foods and more fats, oils, sugars, additives and alcohol, is consumed [20]. At the same time, people become more sedentary and levels of physical activity decrease [21]. The result is often an increase in the rate of overweight and obesity [22].

Based on the results related to both food frequency and anthropometry, a transition from the healthier traditional diet to a more Western eating pattern is likely in participants from both rural and urban areas included in the AHA FS study. Although one might have expected the urban participants to be more overweight and to follow a more Western eating pattern than the rural participants, this was not the case. Inadequate frequency of consumption of fruit, vegetables, legumes, and milk were evident. With regard to milk consumption, our results were similar to the findings reported by Nel and Steyn [23] and the CRIBSA study [24].

Sugar was the most frequently consumed food item among all male and female participants in this study, while cooldrinks were the 11th most frequently consumed food. One of the trademarks of the nutrition transition is frequent consumption of sugar [25], with excessive consumption of sugar-sweetened beverages associated with weight gain and obesity [26]. The frequent consumption of sugar in both the rural and urban areas was comparable to the results of the SANHANES-1 report, where a moderate to high sugar intake was identified [8]. A number of other South

African studies have also identified sugar as the most frequently consumed food item. These include results from an urban meta-analysis [23]; the Coronary Heart Disease Risk Factor Study in the African Population of the Cape Peninsula (CORIS) [23]; and the Transition and Health during Urbanisation in South Africa (THUSA) study from the North-West Province (rural men; men and women living in informal settlements; and women from the middle class urban area) [27].

Salt and stock powders were used at a mean frequency of more than once a day by both rural and urban participants. As a result of the negative impact of salt on health, the South African Food-Based Dietary Guidelines (SAFBDG) recommend that salt should be used sparingly [28]. Few studies have reported on the frequency of salt consumption, but results from the South African Demographic and Health Survey (SADHS) indicated that 48.3% of urban black men and 43.9% of urban black women consumed salty snacks three or more times per week [29]. In an attempt to reduce the disease burden of hypertension related to sodium intake, new South African legislation focuses on reducing the sodium content in staple foods such as bread and cereals [30].

The importance of the quality or type of fat in the diet warrants a food-based dietary guideline [31]. Relatively frequent consumption of foods such as brick margarine and sunflower oil, was identified in the current study, especially by women who consumed these foods at a mean frequency of at least once per day. Other studies that have reported frequent consumption of these foods include SANHANES-1 [8]; the Black Risk Factor Study (BRISK) study [23]; the CORIS study [23]; and the THUSA study [27].

The SAFBDG recommends that South Africans should “eat plenty of vegetables and fruit every day” [32], since there is convincing evidence that fruit and vegetables provide protection against NCDs [1, 33]. Overall, the consumption of fruit and vegetables is very low in South Africa [18]. Fruit and vegetables were consumed at a mean frequency of less than once a day in all groups, contributing to a low intake of micronutrients and fiber. Low intake of fruit and vegetables has also been reported by other South African studies [32]. Participants in the CRIBSA study consumed an average of only 2.2 to 2.6 portions of fruit and vegetables daily [24]. SANHANES-1 reported that both fruit and vegetables were consumed less frequently in rural areas compared to urban areas [8], although the results of the current study showed that rural participants consumed fruit more frequently than urban participants. Rural participants in the AHA FS study were more likely to have fruit trees compared to urban participants [13].

Overweight, obesity and high waist circumference are closely associated with an increased risk for developing NCDs [1, 9], which was also found in the AHA FS study [14]. The disease burden of excessive weight gain in South Africa contributed to 7% of all deaths in the year 2000, with the national burden approximately double in women than in men [25]. However, in the AHA FS study, the burden was approximately threefold in women compared to men. The prevalence of overweight and

obesity in women (rural 65.6%; urban 66.2%) was similar to the SANHANES-1 findings (64% of all African women). However, fewer men from the AHA FS sample were overweight (rural 23.3%; urban 16%) compared to 30.7% of all African men in SANHANES-1 [8].

The higher mean age of rural AHA FS participants, and the likelihood that more rural participants with existing NCDs participated in this study due to the free medical examination provided, might have contributed to the high rates of overweight and obesity seen in rural participants. On the other hand, based on previously reported findings [15], the higher prevalence of HIV in the urban sample (41%) compared to the rural sample (17%) [15] could be the most likely explanation for differences in anthropometric variables. Since a large number of rural men were farm labourers, the high percentage of underweight in rural men might also be due to the high level of physical activity required by the occupation [14].

In the current study, 63.2% of stunted children in the rural areas and 71.8% in urban areas resided with an overweight/obese caregiver. Similarly, two thirds of both rural and urban underweight children and the majority of the wasted children lived with an overweight or obese caregiver, thus confirming a double burden of malnutrition in these rural and urban areas. The high prevalence of stunting, underweight and wasting in children and obesity in adults represents the co-existence of over- and undernutrition [1, 19]. This phenomenon includes the double burden of undernutrition-related infections and the overnutrition-related NCDs [19], placing a burden on social, economic and healthcare systems [34]. In addition to the findings reported here for the Free State Province, various other studies have found similar results in the majority of the provinces in South Africa [9].

Strengths and limitations of using a qualitative FFQ to assess dietary intake are acknowledged. The advantage of the food frequency approach is that it can provide more representative information on usual intake of specific foods than a few days of records or recalls. The fact that only certain foods were included in the FFQ did not allow an assessment of all foods that were consumed by participants. The qualitative nature of the assessment also meant that details on accurate quantities or portion sizes were not determined and thus it was not possible to assess energy or nutrient intake. A full assessment of diet, however, is considered unnecessary when the aim is to measure intake of a specific dietary behavior (e.g. consumption of foods high in fat, salt or sugar).

5. Conclusions

A nutrition transition and double burden of malnutrition were confirmed in both the rural and urban study areas. It is possible that further shifts in dietary patterns may have occurred since the collection of data for the current study and thus an updated

study is recommended. We agree with the opinion of Mchiza et al. [18] that with correct interventions, the nutrition transition can be steered towards a more healthy population. In view of this approach, the development of effective public health policies and a focus on appropriate, culturally acceptable educational and health promoting programmes in the Free State Province is needed urgently. For interventions to be successful, the Government needs to make nutrition a national priority. One approach is to apply the six steps to achieving nutrition transformation proposed by Save the Children Fund [35], that include (i) making malnutrition visible; (ii) investing in direct interventions; (iii) filling the gap in health workers; (iv) protecting families from poverty; (v) harnessing agriculture to address malnutrition; and (vi) galvanising political leadership. By decreasing the burden of disease in developing countries, it is possible to encourage sustainable livelihoods that may ultimately contribute to the eradication of poverty.

Declarations

Author contribution statement

Corinna Walsh: Conceived and designed the experiments, Performed the experiments, Analyzed and interpreted the data, Contributed reagents, materials, analysis tools or data, Wrote the paper.

Reinette Tydeman-Edwards: Performed the experiments, Analyzed and interpreted the data, Wrote the paper.

Francois Cornelius Van Rooyen: Analyzed and interpreted the data.

Funding Statement

This work was supported by a grant from the South African National Research Foundation.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

Dr Daleen Struwig, medical writer, is acknowledged for assistance with proofreading.

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