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Anemia, Iron Deficiency and Diet Independently Influence Growth Patterns of School Aged Children in South Africa

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Abstract

Objective: To determine the differences that exist in the growth indicators of primary school-aged children and to estimate the burden of disease attributed to anaemia, iron deficiency and lack of dietary diversity.

Design: This cross-sectional study assessed growth status by determining anthropometric indicators and motor development. Information on dietary diversity and eating patterns was collected based on meals consumed at home and at school. Laboratory assays were conducted on venous blood samples to assess haemoglobin levels and body iron status.

Setting: Children were recruited from a disadvantaged community in Kwazulu-Natal, South Africa.

Subjects: A study population of 184 children aged six to eight years was enrolled.

Results: The stunting prevalence was 8.3% for boys and 6.6% for girls. Stunted growth was significantly associated with prevalence of parasitic infection (17.7%) ($p=0.01$) and prevalence of anaemia (23.4%) ($p=0.03$). A low prevalence of motor development impairments was found. Anaemia and iron deficiency were significantly related with impaired fine motor skills ($P>0.05$). The diets of 46.7% of the study population met the definition of minimum dietary diversity. Occurrence of nutritional deficiencies in children with low dietary diversity was twice as high as in children with adequate dietary diversity. A significant relationship was noted between low dietary diversity (seven-day recall) and anaemia ($p=0.004$).

Conclusion: These findings provide evidence of the relevance of anaemia and dietary diversity to childhood growth, reinforcing the importance of effective actions to optimize children's dietary intake to achieve better health outcomes.

Keywords: Anthropometry, Growth, Dietary Intake, Anemia, Iron Status

Abbreviations: IDA: Iron Deficiency Anemia; ID: Iron Deficiency; NIDA: Non-Iron Deficiency Anemia; SANHANES: SA: South Africa; HAZ: Height-for-Age Z-scores; WAZ: Weight-for-Age Z-scores; BAZ: BMI-for-Age Z-scores; DDS: dietary diversity score; SD: Standard Deviation; NSNP:National School Nutrition Program; Hb: Hemoglobin level; CRP: C-reactive protein; SF: Serum Ferritin; s TfR: soluble Trans ferric Receptor; IDS: Iron Deficient Stores; MA: Mixed Anemia; NA: Non-Anemic

Introduction

Nutrition is a key factor in the control of many diseases of public health significance. In early childhood, iron deficiency is the most prevalent nutritional disorder [1]. Iron deficiency anaemia (IDA) in preschool children from the developing world has been estimated at 56% [1] and in South Africa (SA) this is seen more commonly in children from particular ethnic groups, namely African and Coloured, as well as children disadvantaged by poor socioeconomic circumstances [2]. The 2013 SANHANES-1 report described a declining anaemia trend of 10.5% and iron deficiency of 8.1% among South African children aged up to 14 years [3]. Among SA children aged less than five years 12% are estimated to be underweight, and 25% stunted [4]. The natural history of nutritional deficiencies associated with anaemia, such as iron deficiency in young children is not yet well defined. The high prevalence of growth deviations and the adverse developmental outcomes associated with malnutrition and anaemia highlight the need for prioritization of nutrition programs. The association between anaemia and psychomotor development has been described by various researchers with evidence suggesting that despite treatment the adverse consequences may not be fully reversible [5,6]. This study was an ancillary exploration to the A sense study which described high levels of anaemia prevalence (53%)[7]observed during their baseline measurements.

Nutritional status is assessed by measuring clinical health status, dietary adequacy, anthropometric and biochemical indicators. These measurements are essential for health screening and for monitoring the response to interventions. Population level growth monitoring is valuable for evaluating group nutrition status within the community as well as for identifying the determinants and burden of disease attributable to malnutrition. Our study describes the variations in nutritional status of school-aged children living in a rural community and explores the relation to anaemia and iron status. This study also describes the contribution of family meals and the school nutritional program to nutritional status and dietary adequacy. The information obtained from this study can contribute to addressing the nutrition-related problems existing in this school-age population and for planning interventions aimed at overcoming these challenges.

Materials and methods

Growth analyses

Anthropometry measurements were conducted by trained research nurses. Under-nutrition in childhood is characterized by growth failure. Height and weight measurements were used as indicators of nutritional status [8]. Height and weight were measured according to standard procedures [9]. Weight measurements were read to the nearest 0.1kg on a portable Philips® digital bathroom scale - model HF340/00. Body height measurements were read to the nearest 0.1cm using a Scales® 2000 moveable stadio meter. Height-for-Age, Weight-for-Age and BMI-for-Age Z-scores for each child were computed using the WHO Child Growth Standards [10]. Anthropometric indices were expressed in the form of z-scores; Height-for-Age Z-scores (HAZ), Weight-for-Age Z-scores (WAZ) and BMI-for-Age Z-scores (BAZ). Underweight was defined as below minus two standard deviations (SD) from the median weight for age of the reference population, while severe underweight was defined as below -3 SD from the median weight-for-age of the reference population. A deficit in height (stunting) was defined as below -2 SD from median height-for-age of the reference population and severe stunting as <-3 SD. A deficit in weight-for-height (wasting) was defined as less than -2 SD from the median weight for height, of the reference population, while severe wasting was defined as < -3 SD [10]. BMI-for-Age Z-scores >1 SD were categorized as overweight, >2 SD as obesity while children with BMI values in the range 0 - 1 SD were at risk of becoming overweight [11].

Motor development was evaluated by a medical doctor who carried out a gross motor skills' examination and a fine motor skills' examination. Motor abilities were characterised into 3 groups: Locomotor, Body manipulation and Object control. Abilities were recorded on a log with a pass or fail mark. Each individual's overall assessment was then categorised as normal, suspect or delayed.

Dietary intake assessment

Home diet: Two structured questionnaires were used to describe intake patterns and dietary diversity of food consumed at home; a non-quantified 24-hour-recall and a 7-day-recall. Both questionnaires were assessed for content validity by a professional nutritionist, familiar with locally available foods, and for face validity in a pilot sample of 10 community members. The questionnaires were interviewer administered by trained research nurses, to the children's caregivers. For the 24 hour-recall, caregivers were asked to recall all foods and beverages consumed by the children in the previous 24 hours, starting with the most recent meal and working backwards. Additional information on dietary diversity was obtained from a seven-day recall of foods consumed in the preceding week. Each food was assigned to one of 9 food groups used to evaluate the diet quality index: 1. Cereal, White roots and tubers; 2. Vitamin A rich vegetables and fruit; 3. other vegetables; 4. other fruits; 5. Meats; 6. Eggs; 7. Legumes, nuts and seeds; 8. Milk and milk products; 9. Oils and fats; and sweets. A dietary diversity score (DDS) was calculated by adding the total number of different food groups consumed. A DDS < 4 was a reflection of poor dietary diversity [12].

School diet: Study participants were enrolled at eight local schools that provided a meal within the National School Nutrition Program (NSNP) and therefore, to obtain a complete picture of their daily food intake necessitated the collection of information about meals consumed at home and at school. To obtain insight into the food consumed at each school, 20 randomly selected children were discretely observed during a meal. Meals were described in terms of foods offered, ingredient availability as well as the served versus consumed portion per child. The information collected was related to program guidelines and recommendations.

Anaemia analysis: Venous blood samples were analysed at an accredited local laboratory. Tests for haemoglobin level (Hb), C-reactive protein (CRP), serum ferritin (SF) and soluble transferrin receptor (s TfR) were conducted to assess anaemia and iron status. The body iron assessment was based on the ratio of sTfR to SF as defined by Cook et al. in the equation: body iron (mg/kg) = - [log10 (sTfR * 1000/SF) -2.8229)]/0.1207). The limits for the outcome measures were: (a) anaemia: Hb<11.5g/dl [13] (b) ID: body iron stores <0mg/kg [14]; and (c) inflammation: CRP≥5 [15]. The children were categorized into five groups based on anaemia and iron status; iron deficiency anaemia (IDA) - anaemia and low body iron stores; non-iron deficiency anaemia (NIDA) - anaemia in the presence of inflammation in a child with normal body iron stores; iron deficient stores (IDS) - depleted iron stores in a non-anaemic child; mixed anaemia (MA) for participants with anaemia in the presence of both iron deficiency and inflammation and non-anaemic non-iron deficient (NA) – where the child had normal haemoglobin concentration and normal iron status. Stool and urine samples were also collected and sent to a local academic laboratory for microscopy and analysis for parasites.

Statistical considerations: Data were entered daily into a predesigned electronic database using SPSS version 22 software package and cleaned regularly. The differentiation between genders was conducted for anthropometric outcomes, because of expected differences between boys and girls. Z-scores and standard deviations (SD) were used as reference standards

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indicating deviation from the mean. WHO anthropometric tables for adolescents aged 5-19 years were used to analyse growth indicator data and to determine impairment of growth by assessing the relationship of the Z-score to the mean. Dietary intake data were analysed by the principal investigator (TPG) and verified by a registered dietician. Nutrient intakes were reported as means and SD. Frequencies were used to determine the percentage of subjects with nutrient intakes < 100% of the dietary reference intakes. The Student's t-test was performed to test the gender difference in HAZ, WAZ and BAZ. Analysis of variance (ANOVA) test was performed to assess the differences in mean values of anthropometric indices by age. Correlation analysis (r) was also conducted to evaluate the strength of the relations between variables such as anaemia prevalence by age and gender. Poisson regression with robust standard error analyses was conducted to examine associations between anaemia and various covariates of interest, such as dietary diversity and growth characteristics. Results were reported as point estimates with 95% confidence intervals.

Results

Population characteristics

In total n=184 children participated in this study. The children were aged 6.5 ± 0.55 years. More males participated 108/184 (58.7%) than females 76/184(41.3%). The difference in age between the boys and girls was not statistically significant. The children were all asymptomatic for anaemia, iron deficiency or any ill-health, but 5/181 (2.8%) of the children tested positive for HIV infection.

Child growth

Anthropometry

The mean BMI for boys was 16.0 ± 1.40kg/m2, for girls 16.45 ± 2.06kg/m2 and overall for the study population 16.21 ± 1.71kg/m2. The overall prevalence for stunting was 14/184 (7.6%), underweight 4/184 (2.1%) and wasting 2/184 (1.1%). More boys 9/108 (8.3%) were stunted than girls 5/76 (6.6%) Severe stunting was observed in 1/184 (0.5%) boy and stunting in 13/184 (7.1%) of which 5/76 (6.6%) were girls and 8/108 (7.4%) boys. Underweight was observed in 2/108 (1.9%) boys and 2/76 (2.6%) girls. Severe underweight for age was identified in a boy 1/184 (0.5%). Wasting results showed 1/184 (0.5%) boy who was severely wasted and 1/184 (0.5%) girl who was wasted. Of note is that the same boy who was severely wasted was also severely stunted and severely underweight. This child was HIV negative, non-anaemic, body iron stores were normal, inflammatory markers were not elevated and had no parasitic infection detected. Conversely, 34/184 (18.5%) of these children had a high risk of becoming overweight. 4/184 (2.2%) children were overweight and 2/184 (1.1%) were obese - one girl and one boy. The majority of children 87/184 (90.7%) were of normal weight. (Table 1): Descriptive statistics for child anthropometric indicators, n=184.

Table 1: Descriptive statistics for child anthropometric indicators, n=184.

	HAZ	WAZ	BAZ
Mean ± SD	-1.07 ± 1.03	-0.55 ± 1.03	-0.13 ± 0.96
n below −2 SD, (%) (95% CI)	13/184 (7.1%) (4.2, 11.7)	3/184 (1.6%) (0.6,4.7)	1/184 (0.5%) (0.6, 4.7)
n below −3 SD, (%) (95% CI)	1/184 (0.5%) (0.1,3.0)	1/184 (0.5%) (0.1, 3.0)	1/184 (0.5%) (0.1, 3.0)

HAZ: Height-for-Age Z-scores; WAZ: Weight-for-Age Z-scores; BAZ: BMI-for-Age Z-scores

Motor skills

A low prevalence of motor impairments was noted. One child was identified as having an abnormal gait which occurred during both walking and running (ICF b770). Poor control and coordination of voluntary movements (ICF b760) was identified in 7/184 (3.8%) of the sampled population. Fine motor evaluation showed that 7/184 (3.8%) of sampled children experienced difficulties with fine motor hand use including the manipulation of fingers and hands when handling small objects (ICF d4402). The presence of anaemia was significantly associated with impaired fine motor skills (p=0.009). An iron deficient status was also significantly associated with impaired fine motor skills (p=0.023). However, due to the small quantities of affected children with the outcome variables such as gross motor development, conclusions could not be drawn concerning the relationship between motor development and anaemia, diet and iron deficiency as this was inadequate for drawing statistical conclusions.

Dietary intake

Dietary diversity had a significant association with stunting as a main effect (r=0.185, p<0.05), and was associated with less dietary diversity using the seven day recall.

Home diet: dietary diversity and eating patterns

The children consumed mainly cereals. The consumption of protein-rich foods both of plant and animal origin was low. Food items such as organ meat, legumes, nuts, seeds, fish and seafood were consumed by less than 15% of the study group. Vegetables were consumed more frequently than fruits. The consumption of vitamin-A rich fruits and vegetables was much lower than that of non-vitamin-A-rich fruits and vegetables. Consumption of dark green leafy vegetables was low although 60% of the children had this at least once in seven days.

The 24-hour dietary diversity score (DDS) was generally low with a maximum score of 7/9 food groups in 2/184 (1.1%), 95%CI (0.3, 3.9%) and a minimum of 1/9 food groups in 2/184 (1.1%) 95% CI (0.3, 3.9%) children. The diversity scores were normally distributed with a mean score of 3.70 (SD 1.13). Feeding patterns for the seven-day recall were comparable to the 24-hour recall though higher food frequency scores were documented. The range was wider with a minimum score of 1/9 food groups consumed for 23/184 (12.5%), 95% CI (8.5, 18.1%) and a maximum 8/9

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food groups, for 7/184 (3.8%), 95% CI (1.9, 7.6%) children. A higher mean score of 4.07 (SD 1.96) was observed over the seven-day recall period. (Table 2): Diversity in feeding practices.

Table 2: Diversity in feeding practices.

	FOOD GROUPS	24 hours		7 days	
		Mean	*SD*	Mean	*SD*
1.	Cereal, White roots and tubers	1.00	0.00	1.00	0.00
2.	Vitamin A rich vegetables and fruit	0.28	0.45	0.55	0.50
3.	Other vegetables	0.76	0.43	0.60	0.49
4.	Other fruits	0.03	0.18	0.12	0.33
5.	Meat	0.66	0.47	0.52	0.50
6.	Eggs	0.11	0.32	0.29	0.45
7.	Legumes, nuts and seeds	0.40	0.49	0.14	0.34
8.	Milk and milk products	0.17	0.38	0.39	0.49
9.	Oils and fats	0.28	0.45	0.45	0.50
	*Sweets	0.39	0.49	0.67	0.47
	*Tea	0.36	0.48	0.75	0.43

Most 91/184 (49.5%) 95% CI (42.3,56.6%) children had a flexible meal plan and often missed meals, although 41/184 (22.3%) 95% CI (16.9, 28.8%) ate three meals plus a snack, 28/184 (15.2%) 95% CI (10.8, 21.1%) had three meals without snacks and 12/184 (6.5%) 95% CI (3.8, 11.1%) had two meals plus snacks. Of the children sampled 2/184 (1.1%) 95% CI (0.3, 3.9%) had gone without food for at least 24 hours in the week preceding the interview. Most children 168/184 (91.3%) 95% CI (86.2, 94.6%) ate the same food as that prepared for the rest of the family. Only 94/184 (51.1%) 95% CI (43.9, 58.2%) caregivers acknowledged that their children ate food from a school feeding scheme. Whether or not the children ate food at the school feeding scheme no differences were observed with stunting or the presence of anaemia.

School meals

There were 160 children from eight schools who participated in the school sub-survey. The schools generally selected children to be fed in the program and did not feed all learners. The food was served inside a classroom during break time and children chose whether or not to come there. Serving sizes were mostly predetermined and did not vary according to children's needs, age or size. A uniform serving potion was used, usually a large dishing spoon 3/8 (37.5%) or a cup 5/8 (62.5%). The proportion consumed by the child was generally high 80-100%. Second servings were infrequently observed 19/160 (11.9%) 95% CI (7.7, 17.8%). The school menu guidelines were not strictly followed though used as a guide, as some ingredients listed on the menu were missing. The food observed was rich in cereals and tubers (100%), non-vitamin-A-rich vegetables 7/8 (87.5%) 95% CI (52.9, 97.8%), meat 5/8 (62.5%) 95% CI (30.6, 86.3%) as well as legumes, nuts and seeds 4/8 (50.0%) 95% CI (21.5, 78.5%). No eggs, milk or milk products were observed at the time of the study in any of the schools. All schools assessed provided meals during weekdays and not on weekends, school holidays or public holidays. No take-home rations were given to children in the observed schools.

Biochemical measurements: serum iron concentrations

The mean Hb level for this sample was 12.17 ± 1.2g/dl. Anaemia was detected in 43/184 (23.4%) 95% CI (17.8, 30.0%) children. The severity of anaemia was mostly mild 24/43 (55.8%) 95% CI (38.9, 67.5%) and moderate 18/43 (41.9%) 95% CI (28.4, 56.7%), only 1/43 (2.3%) 95% CI (0.4, 12.1%) child had severe anaemia. Of the children sampled, 13/184(7.1%) 95% CI (4.2, 11.7%) had tissue iron depletion and of these 9/13 (69.2%) 95% CI (42.4, 87.3%) were anaemic. Stunting and underweight were noted to be worse in children who were iron deficient and anaemic but was not statistically significant ($p>0.05$). Table 3 - Relationship of mean anthropometric indicators with children's anaemia and iron status.

Table 3: Relationship of mean anthropometric indicators with children's anaemia and iron status.

	HAZ mean ± SD	WAZ mean ± SD	BAZ mean ± SD	n (%) (95%CI)
IDA	-1.57 ± 0.79	-0.71 ± 0.49	0 ± 0.58	7 (3.8%) (1.8, 7.6%)
NIDA	-1.15 ± 1.18	-0.62 ± 1.07	-0.09 ± 0.87	34 (18.5%) (13.5, 24.7%)
MA	-2.0 ± 0.0	0.5 ± 0.71	1.50 ± 0.71	2 (1.1%) (0.3, 3.9%)
IDS	-0.50 ± 1.29	-0.75 ± 0.96	-0.75 ± 0.5	4 (2.2%) (0.8, 5.5%)
NA	-1.02 ± 1.0	-0.54 ± 1.04	-0.15 ± 0.99	137(74.5%) (67.7,80.2%)

IDA: Iron Deficiency Anaemia; NIDA – Non-Iron Deficiency Anaemia; IDS: Iron- Deficiency Syndrome; NA: Non-Iron Deficient Non-Anaemic; MA: Anaemia With Iron Deficiency + Inflammation; HAZ: Height-For-Age Z-Scores; WAZ: Weight-For-Age Z-Scores; BAZ: BMI-For-Age Z-Scores

HAZ values in children with NIDA ranged widely as did those for non-anaemic, non-iron deficient children (Figure 1). Moreover, the prevalence of stunting was surprisingly high among non-anaemic non-iron deficient children (NA). Despite the trends noted, the iron status of the children did not indicate any significant associations with growth status. A significant relationship was however noted between low dietary diversity from the seven day

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recall and anaemia (p=0.004) Figure 1 - Distribution of height-for-age in different anaemia and iron status groups.

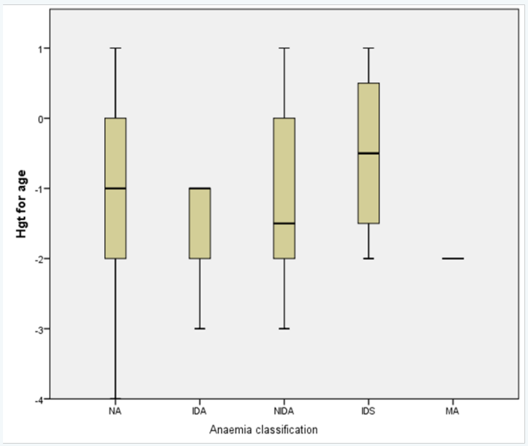

Figure 1: Distribution of height-for-age in different anaemia and iron status groups.

Parasitic infection

Samples of urine and stool were collected from 181/184 (98.4%) children. Positive microscopy findings were identified in 49/181 (27.1%) 95% CI (21.1, 34.0%) of children although pathologic infections were present in 32/181 (17.7%) 95% CI (12.8, 23.9%). The pathologic organisms identified were presented in (Table 1). None of the sampled children had Taenia or Entamoeba histolyticainfection. Stunted growth was significantly associated with parasitic infection (p=0.01) Figure 2 and anaemia (p=0.03). Table 4- Parasitic prevalence and the association with anaemia and stunting. Figure 2- Study profile of children with parasite infestation and growth impairment.

Table 4: Parasitic prevalence and the association with anaemia and stunting.

Parasite	Positive microscopy	Anaemia	Stunting
Ascarislumbricoides	11/181 (6.1%)	4/11 (36.4%) 95% CI (15.2, 64.6%)	1/11(9.1%) 95% CI (1.6, 37.7%)
Enterobiusvermicularis	2/181 (1.1%)	0	No difference
Schistosoma haematobium	3/181 (1.7%)	1/3 (33.3%) 95% CI (6.2, 79.2%)	No difference
Giardia lamblia	18/181 (9.9%)	1/18 (5.5%) 95% CI (1.0, 26.9%)	7/18 (38.9%) 95% CI (20.3, 61.4%)
Entamoeba coli	8/181 (4.4%)	2/7 (28.6%) 95% CI (8.2, 64.1%)	No difference

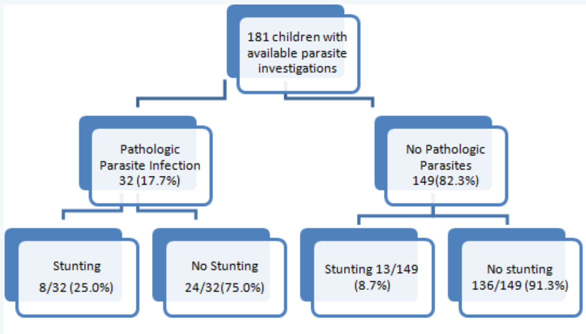

Figure 2: Study profile of children with parasite infestation and growth impairment.

Multivariate analysis - anaemia association

The presence of anaemia was significantly more likely to be associated with iron deficiency (RRR<0.005 [0.968, 2.584]) and the presence of inflammation/infection (RRR< 0.05 [-0.04,-0.003]) than with biological, dietary and nutrition indicators such as worm presence (RRR>0.05 [-0.81, 0.92]), poor dietary diversity (RRR>0.05 [-0.51, 1.02]) or growth stunting (RRR>0.05 [-1.59, 1.31]).

Discussion

This study provided supplementary evidence of a relationship between the growth indices and anaemia, diet and iron deficiency. The children's growth patterns were affected by the levels of nutritional risk in the sampled population. The children's growth in the presence of anaemia and iron deficiency varied independently of the dietary diversity. The small numbers of children identified with some of the outcome variables however meant that conclusions on motor development could not be drawn.

This current study identified high rates of stunting among the sampled children. The stunting rates were similar to, though lower than stunting rates reported in other findings for South African children of the same age group. Anaemia was significantly associated with low dietary diversity as well as stunting and underweight. Dietary diversity was significantly associated with stunting. This study did not any observe significant differences in growth or dietary diversity for children with IDA and those with NIDA. The motivation for this study was the high mortality globally, attributed to under-nutrition. According to the 2013 report by the Maternal and Child Nutrition study group, under-nutrition accounted for 45.0% of children's deaths which was equivalent to more than three million deaths annually. An estimated 165 million children had stunted growth resulting in compromised intellectual and physical development [16].

Growth indicators

Anthropometric findings from this study were compared to outcomes from the South African National Health and Nutrition

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Examination Survey-one (SANHANES-1), six to nine year-old children [3]. Anthropometric indicators for children in this study were similar though marginally lower when compared to the national estimates for children of the same age. Stunting prevalence, boys (8.3%) and girls (6.6%) were lower than the national rates of 10.0% for boys and 8.7% for girls of the same age. Wasting (1.0%) and underweight (2.1%) were also lower than the national prevalence of 2.4% and 9.4% respectively. For boys in this study, the mean weight (23.6kg) and height (118.3cm) was lower than the national mean for six to nine year old boys of 24.4kg, 123.2cm respectively. The mean BMI for boys was comparable, being 16.0kg/m2 in this study and 15.9kg/m2 nationally. These differences were similar to findings for girls where the mean weight (23.2kg) and height (118.3cm) were also lower than the national mean for six to nine year old girls of 25.4kg and 123.9cm respectively. Girls' mean BMI for this study was 16.45kg/m2 while the national estimate was 16.40kg/m2. The difference between genders has been observed in other comparable studies, reporting stunting for boys (19.1%) and girls (7.5%) [17]. Growth impairment was more prevalent in males than females.

The trends in under-nutrition in this study are in accordance with those observed in previous national surveys that consistently identified stunting as the most prevalent form of under-nutrition; followed, to a lesser extent by underweight and wasting [3,18-21]. While it is encouraging that there is an overall decline in stunting, our results show little difference from a 2001 study of eight to ten year olds, also in rural KwaZulu-Natal, that reported a 7.3% prevalence of stunting [22]. Apart from infections, stunting and under-nutrition are issues of chronic poor feeding practices [23] and poor food accessibility [18]. This study provided insights into both these factors through measures of dietary diversity and eating habits.

Dietary diversity

The seven-day DDS was higher than the 24-hour DDS, highlighting the importance of multiple assessments versus a single day recall, in order to account for day to day variability. Nevertheless, the mean seven-day dietary diversity was still low (4.07 ± 1.96), although somewhat higher than that of the 1999 National Food Consumption Survey (NFCS) of children aged one to eight years who had a mean DDS of 3.58 ± 1.37 [18]. In the NFCS, the DDS was related to stunting, underweight and wasting, whereas in this present study a significant association was only identified between dietary diversity (seven-day recall) and stunting. A similar finding was reported by an 11-country demographic survey [24].

Dietary diversity is an indication of food accessibility, providing a perspective on food security of the child's household [18]. National food surveys revealed an overall trend of improved food security from 1999 to 2008. However, food insecurity and hunger still prevail, with rural households being at a higher risk [18, 25]. Recently it was shown that 17.0% of SA households have restricted food access with a greater number (20.9%) affected in KZN [24]. Subsequently, poorer households spend more money on staple foods, mainly maize meal and less on costly fruits and vegetables [24]. A major concern about this population's diet was the low intake of fruits and vegetables (Table 2). In the week reviewed, more than 40.0% did not consume any fruits or vegetables. Additionally, the dietary diversity scores as well as the school dietary data collected suggest a low dietary intake of iron-rich foods from plant and animal sources. While inaccurate recall and underreporting are factors, it is unlikely to explain this trend. Lack of knowledge and poor food choices, inadequate storage facilities and far distances in rural areas are also considerations. In some food insecure families though, as food becomes scarcer, more dire measures are taken, such as the omitting of meals. A 2008 survey confirmed that 25.1% of children's meals were cut, while 16.2% of children went to bed hungry [18]. In this study 2/184 (1.1%) children had gone without food for at least 24 hours in the preceding week.

Poor eating practices raise the risk of micronutrient deficiencies. Promotions to encourage subsistence farming may enable increased consumption of fruits, vegetables and animal-source food [26,27]. This study area was rural and had very low levels of subsistence farming [24]. In South African a staple food fortification program has also been implemented to help reduce the threat of micronutrient deficits in the population [28]. However, it has been argued that the continued, albeit reduced prevalence of stunting may indicate that the food fortification initiative has had little influence on dietary diversity [18].

The National School Nutrition Program (NSNP) is a further public health initiative to address food insecurity and relieve short term hunger [25]. In this study, only 51.1% of the children ate food provided by the school feeding scheme. Encouragingly, some researchers have shown improvements in dietary intake and diversity [25], though there have also been some reports of challenges at some schools [29]. Likewise, in this study, the challenges that schools faced were mostly regarding limited food supply and restricted availability of prescribed menu foods. Few schools had an adequate food variety score. A previous report also highlights that the NSNP aims to improve long term feeding practices through nutrition education in schools [25]. This is targeted at improving long-term dietary habits by improving food choices and combating negative eating practices such as high intakes of sweets and missing of meals seen in this study.

Anaemia and iron status

The results of this study show that anaemia remains a common problem in school-aged children (23.4%). Iron deficiency was identified in 7.1% of the sampled children and was a significant contributor to the prevalence of anaemia. These iron status findings were comparable to the 2012 SANHANES-1 survey where the national prevalence for iron deficiency was 8.1% [3]. The high anaemia prevalence reported in this study was however in contrast to the SANHANES-1 report which showed a declining trend in anaemia (10.5%) for children aged up to 14 years.

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Two studies conducted in Kwazulu-Natal reported an anaemia prevalence of 16.5% and 22.0% in school age children [30,31]. The persistently high anaemia prevalence in this study population may be attributed to anaemia of inflammation resulting from chronic poorly managed infections.

Limitation

This investigation had a cross-sectional study design hence trends over time and the temporal sequence between exposure (anaemia, iron deficiency and dietary diversity) and outcome (growth) could not be evaluated. Hence the cause-effect relationship could not be determined. This cross-sectional study measured prevalence and not incidence which could result in prevalence-incidence bias as long-standing cases of anaemia and dietary insufficiency may have been over-represented while short-lived cases may be under-represented. Current exposure and outcome were measured simultaneously; hence recent changes to the anaemia status or dietary pattern in growth impaired children were overlooked. The proportion of children no longer affected by growth impairment, anaemia or iron deficiency could not be assessed as this study did not test for evidence of past disease.

Conclusion

The overall findings from this study provide evidence of the benefits of a diverse overall diet and suggest the improvements required to enhance the children's growth pattern. Interventions providing dietary support and iron supplementation need to be complemented with attempts to improve the general health and nutritional status of underprivileged children. Long term interventions and policies which target individual, community, and national levels are needed. These may comprise providing routine heath monitoring as well as endorsing healthy locally obtainable wholesome food, consolidating school supplementary feeding programs and providing behavioural modification programs that target child care and hygiene practices relevant to the local cultural practices and financial restrictions. Community based prevention approaches need to be implemented together with secondary prevention by screening and providing treatment to children at risk. Regular, accurate measurement of growth indicators in children and adolescents with the maintenance of up-to-date accessible records for surveillance may be invaluable.

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