Published in final edited form as:
Public Health Nutr. 2007 June ; 10(6): 635–643. doi:10.1017/S1368980007258483.

Energy, macro- and micronutrient intake among a true longitudinal group of South African adolescents at two interceptions (2000 and 2003):

The Birth-to-Twenty (Bt20) Study

Jennifer M MacKeown[1,*], **Titilola M Pedro**[2], and **Shane A Norris**[3]

[1]MRC Health and Development Research Group, PO Box 87373, Houghton, 2041, Johannesburg, South Africa

[2]MRC/WITS Birth-to-Twenty Research Programme, Department of Paediatrics, University of the Witwatersrand Medical School, 7 York Road, Parktown, 2193, Johannesburg, South Africa

[3]MRC Mineral Metabolism Research Unit, Birth-to-Twenty Research Programme, Department of Paediatrics, University of the Witwatersrand Medical School, 7 York Road, Parktown, 2193, Johannesburg, South Africa

Abstract

Objective—This study reports on the energy, macro- and micronutrient intakes of a true longitudinal group of 143 urban black South African children from the Birth-to-Twenty (Bt20) study at two interceptions (2000 and 2003) when they were 10 and 13 years old, respectively.

Methods—Subjects resided in the urban Johannesburg/Soweto area of the Gauteng Province in South Africa. Dietary intake was assessed using a semi-quantitative food-frequency questionnaire. The coded data were analysed using SAS.

Results—Mean daily intake of energy, all six macronutrients and most micronutrients (17/19) increased from 2000 to 2003. Of the 19 micronutrients investigated, the mean daily intake of eight (calcium, iron, zinc, vitamin A, riboflavin, nicotinic acid, pantothenic acid and biotin) fell below the recommended dietary allowance (RDA) at both interceptions. More than 70% of the children consumed less than the RDA for these same eight nutrients. From 2000 to 2003, there was a decrease in the percentage of children falling below the RDA for energy (from 73 to 59%), but an increase in the percentage of children falling below the RDA for most of the micronutrients. There was a positive percentage change in mean daily intake for all 26 macro- and micronutrients from 2000 to 2003.

Conclusion—Mean daily intake of nutrients increased from 2000 to 2003, but intakes for most micronutrients were still below the RDA at both interceptions for a large percentage of the children. The study has provided valuable information on the nutrient intake and change in intake over time among a longitudinal group of South African adolescents.

Keywords

South Africa; Adolescents; Longitudinal; Nutrient intake

Corresponding author: Email jenny.mackeown@mrc.ac.za.

Europe PMC Funders Author Manuscripts

The African continent as a whole is known to be the only one in the world in which the prevalence of malnutrition continues to be high, with little evidence of any meaningful or consistent improvement in nutritional status[1]. Projected estimates for 2015 have indicated that 33% of the world's underweight children will live in the African continent[2]. In addition, there is ample evidence that nutrient deficiencies as well as protein–energy malnutrition are important in shaping growth and health status in the developing world[3].

As a result of the high prevalence of undernutrition[4] and micronutrient deficiencies in South Africa[5] among emerging populations in the nutritional transition, primary and secondary nutritional interventions are essential[6] and scientifically conducted dietary surveys, especially on children, should be carried out regularly, particularly with the changing society, altered food habits, nutritional problems and demands of professional practices in this country[7]. In the urban context, Africans have recently experienced numerous changes in environmental, socioeconomic and dietary factors, and in other respects, thereby undergoing considerable Westernisation of lifestyle compared with the past[8].

However, in developing countries, such as those in Africa, there is a paucity of information available on change in dietary intake over time. The data available have been mainly cross-sectional studies constraining the ability to examine developmental trends over time. This limitation is particularly concerning when we examine the diets of children, since food and nutrient intake may change with physical, social and psychological maturation[9].

Dietary habits and preferences are believed to form in childhood and become habituated over time[10-12]. With the global economic development and urbanisation, there has been a great change in the nutritional status of adolescents worldwide during the past two decades[13]. Some improvements in nutrient intake among youth do occur over time, but, by and large, diets tend to become less nutrient-dense as children move into early adolescence[9]. However, little attention has been paid to adolescent nutrition in developing countries[14], but nutrition among youth has become of increasing interest as evidence accumulates about the role of diet during this time and the risk of subsequent adult diseases[15].

In South Africa in particular, longitudinal nutrition information depicting dietary change over time among pre-adolescent children is completely lacking, with only one study reporting the energy, macro- and micronutrient intakes of a true longitudinal group of children from the Birth-to-Twenty (Bt20) study (previously referred to as the Birth-to-Ten (BTT) study from 1990 to 2000 and the Bt20 from 2001 onwards)[16].

The Bt20 study commenced in 1990 and is a longitudinal observational study, planned to continue to the year 2010, designed to follow factors associated with the survival and health of urban children from all the South African communities living in the Johannesburg/ Soweto area of Gauteng Province. This is the largest and longest running study on children's development in Africa and is also the first and only longitudinal study on the nutrient intakes of South African children, and has thus provided unique information. In addition, the period of this study (1990-2003) coincided with the dramatic socio-political changes taking place in South Africa and provided an ideal opportunity to investigate dietary change in urban South African children over this time.

Objective

This study reports on the energy, macro- and micronutrient intakes of a true longitudinal group of 143 urban black South African adolescents in 2000 and 2003, at 10 and 13 years old, respectively, participating in the Bt20 study.

Europe PMC Funders Author Manuscripts

Methods

Prior to the study, ethical approval was obtained from the University of the Witwatersrand Committee (medical) for Research on Human Subjects. Details of the study design have been reported elsewhere17-20, so only a brief outline is provided.

Population sample

The sample size of each community was originally based on a representative proportional sample of the total South African population according to the 1994 population census21. Hence there was a large difference in numbers between the communities for this study. The black community predominates in South Africa, now comprising 79% of the total population according to the 2001 census22. This fact, together with available numbers of children, resulted in adequate numbers for the longitudinal investigation only from the black community. The number of children in the other groups had dwindled to too few. Nutrition interceptions of the Bt20 study took place in 1995, 1997, 1999, 2000 and 2003 when the children were 5, 7. 9, 10 and 13 years old, respectively. A total of 1096 urban black children provided nutrition information for 1995, 550 for 1997, 304 for 1999, 365 for 2000, and 143 for 2003. A total of 143 urban black children made up the true longitudinal cohort of the Bt20 study having nutrition information at all five interceptions, but only the nutrient intakes of these 143 children at 10 and 13 years old as they enter puberty will be reported. These children’s nutrient intakes at the other interceptions (1995-2000) have been reported elsewhere16.

Dietary assessment

Dietary intake was assessed using the same semi-quantitative food-frequency questionnaire at all interceptions, an appropriate method for large-scale studies such as the Bt20 study, in culturally diverse populations23. A quantitative food-frequency questionnaire proved a reproducible and valid instrument for assessing the dietary intakes of adults and children older than 15 years among the black population in the North West Province, South Africa24,25, and is the present approach used in many South African nutritional studies. Parents or guardians or the children themselves were asked by trained multilingual interviewers to indicate how frequently listed food items were consumed according to the number of days per week. The foods listed in the questionnaire were based on many years of experience in diet assessment among South African children; the questionnaire was designed to obtain a picture of the diet as a whole rather than to rank or categorise selected nutrients. The assistants were initially trained in interviewing and coding, and were monitored throughout the study period, and these same assistants (interviewers and coders) conducted the fieldwork and coded the data for all interceptions. Food items were coded onto computer coding forms using the South African Medical Research Council (MRC) food composition tables and codes26. For certain food items listed, the amounts consumed were recorded in household measures. For other items, standard portion sizes were used based on the use of the National Research Programme for Nutritional Intervention (NRPNI) food quantities manual27. The daily amounts consumed were calculated from the intake frequency, and our nutrition programme was applied to determine the mean daily nutrient intake for each individual.

Data management

The data were analysed using SAS28. The nutrient intake for each individual at each interception was merged to create one large data set from which individual children’s results could be extracted. A specific computer program written by the University of the Witwatersrand Computer and Networking Centre was used to merge the data by child case number to ensure identification of the true longitudinal group. A child seen at all interceptions would keep the same case number with the year ‘95’, ‘97’, ‘99’, ‘00’ or ‘03’ as the prefix. Descriptive statistics were used to determine the daily mean intakes of energy, macro- and micronutrients of the children at each interception, and the 95% confidence intervals of these nutrients were calculated. The mean intakes were compared with the 1989 recommended dietary allowances (RDAs)29, and the percentage of children who fell below the RDA was calculated. The 1989 RDAs were used for consistency as they had been used as the standard in all the previous interceptions. The percentage change in mean daily nutrient intake between interceptions and the 95% confidence intervals of the percentage change were also calculated.

Results

The mean intake of energy, all six macronutrients and most micronutrients (17/19) increased from 2000 to 2003, with protein and fibre among the macronutrients increasing only slightly. Of the 19 micronutrients investigated, eight (namely calcium, iron, zinc, vitamin A, riboflavin, nicotinic acid, pantothenic acid and biotin) fell below the RDA at both interceptions, while seven (namely vitamin B_{12}, magnesium, potassium, thiamin, folic acid, vitamin E and manganese) met the RDA in 2000 and 2003. Vitamin B_6 and ascorbic acid fell below the RDA in 2000 only, and phosphorus and copper fell below the RDA in 2003 only (Table 1).

The percentage of energy from fat increased from 25% in 2000 to 29% in 2003, but the percentage contribution from carbohydrate (63% in 2000; 60% in 2003) and protein (12% in 2000; 11% in 2003) decreased between these interceptions (data not shown).

This, however, concealed the fact that a large percentage of the children fell below the recommended intakes even though the daily amounts appeared adequate (Table 2). The percentage of children falling below the RDA for energy decreased from 73% in 2000 to 59% in 2003, but there was an increase in the percentage of children falling below the RDA for 12 of the 19 micronutrients, with the percentage for phosphorus and magnesium increasing by >30% and that for ascorbic acid decreasing by >30% over this period (Table 2). More than 70% of the children fell below the RDA for calcium, iron, zinc, copper, vitamin A, riboflavin, vitamin B_6, pantothenic acid and biotin at both interceptions (Table 2).

Table 3 shows these data as quartiles according to the percentage of children with intakes below the RDA. The number of nutrients decreased within the lower and upper quartiles from 2000 to 2003, but increased within the middle two quartiles. In 2000, <25% of the children fell below the RDA for four nutrients, namely protein, vitamin B_{12}, magnesium and folic acid, and >75% fell below for 10 nutrients. In 2003, <25% of the children fell below the RDA for folic acid only, but >75% fell below the RDA for seven nutrients, namely calcium, zinc, copper, vitamin A, vitamin B6, pantothenic acid and biotin. More than 75% of the children fell below the RDA for these seven micronutrients in both 2000 and 2003 (Table 3).

Figure 1 shows the distribution of all nutrients (limits, quartiles and medians) according to the percentage of children falling below the RDA. There was a narrowing of the distribution of the percentage of children falling below the RDA from 2000 to 2003, with the median percentage decreasing slightly between these interceptions; 75% in 2000 to 65% in 2003.

In addition to reporting the mean daily intake of nutrients compared with the RDA and the percentage of individuals who fell below the RDA, the percentage change in mean daily intake between interceptions was also investigated. Table 4 shows the percentage change in mean daily intake and 95% confidence intervals of these percentages of nutrients between the 2000 and 2003 interceptions, and Fig. 2 shows the distribution of all these nutrients (limits, quartiles and medians) as a percentage of change in mean daily intake between interceptions. Most nutrients showed a positive percentage change in intake between 2000 and 2003. The overall percentage change from 1995 to 2003 for these same 143 children was also positive in comparison with the percentage change from 1995 to 2000, prior to adolescence, which was definitely negative (Fig. 2).

Discussion

Main findings

Most countries are now affected by demographic transition and changing epidemiology of disease; the nutrition of children is increasingly recognised as crucial for present and future health as there is increasing evidence that childhood nutrition also influences adult health. A key factor is the recognition that nutritional interventions at different stages of life are necessary if childhood nutrition is to improve[30]. South Africa has recognised this, and the present study reports unique descriptive information on how the dietary intake of a true longitudinal group of urban black South African children has changed from 2000 to 2003 through two interceptions, but the particular strength of the study is that it is the first, and only, South African nutritional study to describe dietary changes among a true longitudinal cohort. The nutrient intake of this same longitudinal group of urban black South African children did not show an improvement in nutrient intakes from 1995 to 2000[16] before adolescence, but the 2003 interception did show an improvement in mean daily intakes of both macro- and micronutrients from 2000 to 2003 as these children entered adolescence. However, the 2003 interception still showed a large percentage of children falling below the RDA for many nutrients, the percentage increasing from 2000 to 2003 for most nutrients.

Methodology

One must always keep in mind that dietary intake is only an estimate as there is no absolute 'gold' standard, and that dietary intake cannot be assessed without error and probably never will be. However, with the underlying principle of the food-frequency questionnaire approach being that long-term diet is the conceptually important issue rather than intake on a few specific days, its ease of application and cost effectiveness in large-scale studies, such as the Bt20, made this, the semi-quantitative food-frequency questionnaire, the preferred method of choice[31].

In culturally diverse populations, such as in South Africa, however, it may be impossible to develop a food list that is reasonably short while, at the same time, includes all of the essential core foods eaten by a study group[32]. Foods important to an individual's diet may be omitted if they are not mentioned in the questionnaire[33]. The food list in the Bt20 food-frequency questionnaire was based on many years of experience in dietary assessment among South African children, and analysis was based on group, not individual, intake. It is therefore reasonably certain that the questionnaire covered most of the foods consumed by South African children. The fact that group intake was analysed reduced both inter- and intra-individual variation in nutrient intake to some extent. As time passes though, core foods for the cohort may change as may nutrient composition of the foods already present in the questionnaire. It is thus possible that the same questionnaire used repeatedly in this longitudinal cohort may have become obsolete and needed revision[32]. While this is a potential weakness in the methodology of the current study, it is also a strength because it did enable consistency in assessment throughout the study period.

Another possible limitation of the study is the predetermined portion size used in the questionnaire for many of the foods. Guthrie[33] found that young adults were not able to describe their portion sizes accurately. In addition, there is substantial within-person variation in portion size34, which varies less than frequencies in most foods35,36. With most of the variation in a population food intake explained by frequency of use, individual portion size data have been seen as relatively unimportant37.

When children and adolescents are the target population in dietary surveys, many different respondent and observer considerations surface38. The cognitive abilities required to self-report food intake include an adequately developed concept of time, a good memory and attention span, and a knowledge of the names of foods. From the age of 8 years there is a rapid increase in the ability of children to self-report food intake38 and, although it has been found that parents can be reliable reporters of their children's food intake in the home environment, the suitability of parents to be the only informants of their children's intake out of the home is inevitably limited39. Children aged 10 years and older eat much of their food away from home, therefore they are probably the most accurate reporters of their intake. Undoubtedly, blending the method with respondent capabilities is of paramount importance, but to date the limits of accuracy of the various survey instruments when applied to children and adolescents have not been defined38. The food-frequency questionnaire used in the present study was simple and it was almost certain that the children of 10 years and older were able to report how frequently they consumed the listed foods. However, in most cases, parents or guardians were present.

With regard to the population sample, it is a shame that only 143 subjects could be followed longitudinally, but this reflects the difficulty of longitudinal studies. Families moving away from the area or no longer wishing to participate are just two of the many reasons for subject loss. It must also be kept in mind that the original sample size of each community was based on a representative proportional sample of the total South African population according to the 1994 population census21. Hence there was a large difference in numbers between the communities for this study. The black community predominates in South Africa, now comprising 79% of the total population according to the 2001 census22. This fact, together with available numbers of children, resulted in adequate numbers for the longitudinal investigation only from the black community. The number of children in the other groups had dwindled to too few. In addition, there is no indication of whether these 143 children were similar to those lost to follow-up.

Comparisons with other South African studies

There is a general agreement that diet does change over time40, but in South Africa no longitudinal nutritional studies on children have been conducted to assess dietary change and, unfortunately, the available dietary studies on the nutritional status of pre- and primary school children are mostly of a small scale and localised41 and little attention has been paid to adolescent nutrition14. Therefore, comparisons can only be made with cross-sectional studies, which have provided extremely valuable information on the nutritional status of population groups at a particular point in time but have been unable to determine dietary change over time among the same individuals. These cross-sectional studies have been conducted in rural and urban areas; among infants, pre-school and primary school children, adults and the elderly4,7,20,41-53, with most reporting low energy intakes and inadequate micronutrient nutrient intakes.

The South African Vitamin A Consultative Group (SAVACG)4 found that one in three children had a marginal vitamin A status ($<$20 g dl^{-1}). The prevalence of vitamin A deficiency was highest in the rural areas. Additionally, one in five children were found to be anaemic. Faber *et al.50* also found that the poor quality of the diet of rural preschool children was reflected in a poor vitamin A and iron status. The present study was conducted on an older age group than these above-mentioned studies but found 98% of the children at

10 years old and 78% at 13 years old with intakes below the RDA for vitamin A and 71 and 74% below the RDA for iron at 10 and 13 years old, respectively. These percentages were much higher than those reported in the other two studies.

The National Food Consumption Survey (NFCS) of children aged 1-9 years in South Africa41 showed that the majority of children consumed a diet deficient in energy and of insufficient nutrient density to meet their micronutrient recommendations. For South African children as a whole, the dietary intake of energy, calcium, iron, zinc, selenium, vitamin A, vitamin D, ascorbic acid, vitamin E, riboflavin, nicotinic acid and vitamin B_6 was below 67% of the RDA. A large percentage of children (25-82%) of all the age groups had intakes of <50% of the RDA for vitamin E, ascorbic acid, riboflavin, nicotinic acid, vitamin B_6 and folic acid. The mean calcium intake was less than half of that recommended in almost 95% of the children. At the national level, 81-94% of the children had an intake much less than half of the recommended calcium intake. The mean intake of iron and zinc was consistently low in all age groups. At the national level, 41-83 and 52-69% of the children had intakes of iron and zinc, respectively, of less than half of the recommended intake. The present study also found the intakes of calcium, iron, zinc, vitamin A, riboflavin and nicotinic acid to be below the recommended intakes at both interceptions, with >70% of the children falling below the RDA for these nutrients. However, pantothenic acid and biotin were additional micronutrients that fell below the RDA, while folic acid met the RDA at both interceptions for the Bt20 children.

Possibly the only South African study that has tracked nutrient intake over time among the same age group, community and living in the same area is the comparison of energy, macro- and micronutrient intakes of 5-year-old urban black children in 1984 and 1995 living in the Johannesburg/Soweto area20. It was found that the intake of energy and most macronutrients was higher in 1995 than 1984, except for vitamin A, ascorbic acid, copper and iron, and only biotin fell below 67% of the RDA. However, a large percentage of children fell below the RDA for many of the nutrients even though the intakes appeared adequate. It was also reported that the children consumed a typical prudent diet in 1984, but by 1995 the diet was more Westernised. Comparing rural and urban women in the Transition and Health during Urbanisation of South Africans (THUSA) study53, a definite shift in nutrient intake was observed: the percentage of energy from carbohydrates decreased, but the percentage from fat and protein increased. The present study showed that urban black children living in the Johannesburg/Soweto area consumed a characteristic prudent diet low in fat (±30%) and high in carbohydrate (±60%), but within an urban environment there had been an increase in the percentage of energy from fat, and a decrease in the percentage from carbohydrate and protein from 2000 to 2003. Thus there is evidence not only of a nutrition transition from rural to urban but also within an urban environment itself over time.

The only true longitudinal comparative study that tracks nutrient intake over time among the same urban black South African children is an earlier investigation of these same Bt20 children reported on in this study prior to adolescence from 1995 to 2000 (5-10 years)16. The nutrient intake of these children appeared to deteriorate over four interceptions from 1995 to 2000, with the lowest intake for most nutrients recorded in 2000. Calcium, iron, zinc and biotin were the most common nutrients to fall below the RDA at most of the interceptions, with also the largest percentage of children falling below the RDA for these nutrients. Most nutrients showed a negative percentage change in intake from 1995 to 2000. At the 2000 and 2003 interceptions, calcium, iron, zinc and biotin remained the common nutrients that did not meet the RDA, with >70% of the children falling below the RDA for these same nutrients. However, in contrast to the overall percentage change in intake for most nutrients from 1995 to 2000 being negative, the percentage change in intake for these children from 2000 to 2003 was positive for most nutrients.

Although the comparative studies mentioned above have not included children of the same age groups as the present study, the findings emphasise the continuous trend in inadequate micronutrient intake among all age groups in South Africa.

The results of the present study should, however, be interpreted with caution as we only report on the nutrient intake. The actual food items consumed, socio-economic factors, anthropometrical and growth data were not included. Inclusion of this information would give a clearer understanding of the nutritional status of this group of children and would show if there had been an improvement or a deterioration in nutrient intake as they entered puberty. This has been planned for a future publication. To emphasise the importance of this future research, it was stated by Lytle *et al.*[9] that more research is needed on the effects of socio-economic status on the nutritional intake of youth, and further research examining differences in food choice behaviour is very important and needed, especially for intervention studies. Since individuals eat food, not nutrients, we need to learn more about how food choices vary over time.

The finding that moderate stunting coexists with overweight and obesity suggests that patterns of under- and overnutrition in South African children are changing and might indicate the early stages of a complex nutritional transition[54]. This necessitates regular clinical and epidemiological monitoring of nutritional status to examine possible future trends[55], and to state whether a nutrition transition is taking place in South Africa longitudinal monitoring of nutritional status is essential.

Acknowledgments

BT20 is funded by the Welcome Trust (UK), the Human Science Research Council of South Africa, the Medical Research Council of South Africa, the University of the Witwatersrand, Johannesburg and the Anglo-American Chairman's Fund. For information on Bt20, visit www.wits.ac.za/birthto20

References

1. United Nations Children's Fund (UNICEF). The State of the World's Children. UNICEF; New York: 2000. p. 121
2. de Onis M, Blossner M. The World Health Organisation global database on child growth and malnutrition: methodology and applications. International Journal of Epidemiology. 2003; 32:518–26. [PubMed: 12913022]
3. Allen LH. Nutritional influence on linear growth: a general review. European Journal of Clinical Nutrition. 1994; 48:S75–89. [PubMed: 8005094]
4. Labadarios, D.; van Middelkoop, AM., editors. Children Aged 6 to 71 Months in South Africa. 1994: Their Anthropometric, Vitamin A, Iron and Immunisation Coverage Status. The South African Vitamin A Consultative Group (SAVACG); Johannesburg: 1995. Also available at http://www.sahealthinfo.org/nutrition/vitamina.htm
5. Department of Health. Information for Health Workers on Vitamin A Supplementation. Department of Health; Pretoria: 2002.
6. Labadarios D, Steyn NP, Mgijima C, Daldla N. Review of the South African nutrition policy 1994-2002 and targets for 2007: achievements and challenges. Nutrition. 2005; 21:100–8. [PubMed: 15661484]
7. MacKeown JM, Cleaton-Jones PE, Perdrau GG. Energy and macronutrient intake of one-year-old South African urban children: Birth to Ten (BTT) Study. Paediatric and Perinatal Epidemiology. 1996; 10:150–60. [PubMed: 8778688]
8. Walker AR, Walker BF. Lung cancer in Africans in a South African city population in transition. European Journal of Cancer Prevention. 2005; 14:187–9. [PubMed: 15785325]
9. Lytle LA, Himes JH, Feldman H, Zive M, Dwyer J, Hoelscher D, et al. Nutrient intake over time in a multi-ethnic sample of youth. Public Health Nutrition. 2002; 5:319–28. [PubMed: 12020384]

Europe PMC Funders Author Manuscripts

10. Birch LL. Development of food preferences. Annual Review of Nutrition. 1999; 19:41–62.
11. Kovisto Hursti U-K. Factors influencing children's food choices. Annals of Medicine. 1999; 31(Suppl. 1):26–32. [PubMed: 10342497]
12. Kelder SH, Perry CL, Klepp K-I, Lytle LA. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviours. American Journal of Public Health. 1994; 84:1121–6. [PubMed: 8017536]
13. Samuelson G. Dietary habits and nutritional status in adolescents over Europe - Southern Europe. European Journal of Clinical Nutrition. 2000; 54(Suppl. 1):S29–35. [PubMed: 10805035]
14. Shi Z, Lien N, Kumar BN, Dalen I, Holmboe-Ottesen G. The soiciodemographic correlates of nutritional status of school adolescents in Jiangsu Province, China. Journal of Adolescent Health. 2005; 37:313–22. [PubMed: 16182142]
15. US Department of Health and Human Services. Surgeon General's Report on Nutrition and Health. US Department of Health and Human Services; Washington, DC: 1988. p. 626-50.Report No. 88-50210
16. MacKeown JM, Cleaton-Jones PE, Norris SA. Nutrient intake among a longitudinal group of urban black South African children at four interceptions between 1995 and 2000 (Birth-to-Ten Study). Nutrition Research. 2003; 23:185–97.
17. Fonn S, de Beer M, Kgamphe JS, McIntyre J, Cameron N, Padayachee GN, et al. Birth to Ten: pilot studies to test the feasibility of a birth cohort study investigating effects of urbanisation in South Africa. South African Medical Journal. 1991; 79:449–54. [PubMed: 2020885]
18. Yach D, Cameron N, Padayachee GN, Wagstaff L, Richter L, Fonn S, et al. Birth to Ten: child health in South Africa in the 1990's. Rationale and methods of a birth cohort study. Paediatric and Perinatal Epidemiology. 1991; 5:211–33. [PubMed: 2052483]
19. Richter LM, Yach D, Cameron N, Griesel RD, de Wet T. Enrolment into Birth to Ten (BTT): sample and population characteristics. Paediatric and Perinatal Epidemiology. 1995; 9:109–20. [PubMed: 7724410]
20. MacKeown JM, Cleaton-Jones PE, Edwards AW, Turgeon-O'Brien H. Energy, macro- and micronutrient intake of 5-year-old urban black South African children in 1984 and 1995. Paediatric and Perinatal Epidemiology. 1998; 12:297–312. [PubMed: 9690265]
21. Steenkamp, HA. Population Estimates for the RSA by Magisterial District and Province. Bureau of Market Research, University of South Africa; Pretoria: 1994. p. 80Research Report No. 212
22. Statistics South Africa. Statistics South Africa, Census in Brief, 2001. Statistics South Africa; Pretoria: 2003. Report No. 03-02-03Also available at http://www.statssa.gov.za/publications/
23. Hankin JH, Wilkens LR. Development and validation of dietary assessment methods for culturally diverse populations. American Journal of Clinical Nutrition. 1994; 59(Suppl. 1):198S–200S. [PubMed: 8279423]
24. MacIntyre UE, Venter CS, Vorster HH. A culture sensitive quantitative food frequency questionnaire used in an African population 1. Development and reproducibility. Public Health Nutrition. 2001; 4:53–62. [PubMed: 11315681]
25. MacIntyre UE, Venter CS, Vorster HH. A culture sensitive quantitative food frequency questionnaire used in an African population 2. Relative validation by 7-day weighed records and biomarkers. Public Health Nutrition. 2001; 4:63–71. [PubMed: 11315682]
26. Langenhoven, ML.; Kruger, M.; Gouws, E.; Faber, M. Research Institute for Nutritional Diseases (RIND) Food Composition Tables. 3rd ed.. South African Medical Research Council; Cape Town: 1991. p. 248
27. Langenhoven, ML.; Conradie, PJ.; Wolmarans, P.; Faber, M. National Research Programme for Nutritional Intervention. Food Quantities Manual. 2nd ed.. South African Medical Research Council; Parow: 1991. p. 213
28. SAS Institute, Inc.. SAS/STAT User's Guide: Version 6. 4th ed.. Vol. 1. SAS Institute, Inc.; Cary, NC: 1989. p. 943
29. Food Nutrition Board. National Academy of Sciences-National Research Council. Revised Recommended Dietary Allowances. 10th ed.. National Academy Press; Washington, DC: 1989. p. 302

30. Tomkins A. Vitamin and mineral nutrition for the health and development of the children in Europe. Public Health Nutrition. 2001; 4:91–9. [PubMed: 11345062]
31. Kono S, Tokui N, Yoshimura T, Uchioka M, Takewaka H. Review on dietary methods for epidemiologic studies. Sangyo Ika Daigaku Zasshi. 1984; 6:411–8. [PubMed: 6395254]
32. Sempos CT. Invited commentary: some limitations of semi quantitative food frequency questionnaires. American Journal of Epidemiology. 1992; 135:1127–32.
33. Guthrie HA. Selection and quantification of typical portions in young adults. Journal of the American Dietetic Association. 1984; 84:1440–4. [PubMed: 6501752]
34. Hunter DJ, Sampson L, Stampfer MJ, Colditz GA, Rosner B, Willett WC. Variability in portion size of commonly consumed foods among a population of women in the United States. American Journal of Epidemiology. 1988; 127:1240–9. [PubMed: 3369422]
35. Sanet JM, Humble CG, Skipper BE. Alternatives in the collection and analysis of food frequency interview data. American Journal of Epidemiology. 1984; 120:572–81. [PubMed: 6475926]
36. Pickle LW, Hartman AM. Indicator foods for vitamin A assessment. Nutrition and Cancer. 1985; 7:3–23. [PubMed: 4070006]
37. Willett, WC. Nutritional Epidemiology. Oxford University Press; New York: 1980.
38. Livingstone MBE, Robson PJ. Measurement of dietary intake in children. Proceedings of the Nutrition Society. 2000; 59:279–93. [PubMed: 10946797]
39. Eck LH, Klesges RC, Hanson CL. Recall of child's intake from one meal: are parents accurate? Journal of the American Dietetic Association. 1989; 89:784–9. [PubMed: 2723300]
40. British Nutrition Foundation. Eating in the Early 1980's: Summary of the British Nutrition Foundation Survey. British Market Research Bureau; London: 1985.
41. Labadarios D, Steyn N, Maunder E, MacIntyre U, Geriche G, Swart R, et al. The National Food Consumption Survey (NFCS): South Africa, 1999. Public Health Nutrition. 2005; 8:533–43. [PubMed: 16153334]
42. Richter MJ, Langenhoven ML, du Plessis JP, Ferreira JJ, Swanepoel AS, Jordaan PC. Nutritional value of diets of blacks in Ciskei. South African Medical Journal. 1984; 65:338–45. [PubMed: 6701719]
43. Steyn NP, Alberts EC, van Wyk Kotze TJ, van Heerden L, Kotze JP. Analysis of the diets of 12-year-old children in Cape Town. South African Medical Journal. 1986; 69:739–42. [PubMed: 3012802]
44. Bourne LT, Langenhoven ML, Steyn K, Jooste PL, Laubscher JA, Van der Vyver E. Nutrient intake in the urban African population of the Cape Peninsula, South Africa: the Brisk Study. Central African Journal of Medicine. 1993; 39:238–47. [PubMed: 8055556]
45. Bourne LT, Langenhoven ML, Steyn K, Jooste PL, Laubscher JA, Bourne DG. Nutritional status of 3-6 year-old African children in the Cape Peninsula. East African Medical Journal. 1994; 71:695–702. [PubMed: 7859652]
46. Charlton KE, Wolmarans P, Marais AD, Lombard CJ. Macronutrient intake and cardiovascular risk factors in older coloured South Africans. East African Medical Journal. 1997; 74:478–86. [PubMed: 9487411]
47. Jooste PL, Langenhoven ML, Kriek JA, Kunneke E, Nyaphisi M, Sharp B. Nutritional status rural children in the Lesotho Highlands. East African Medical Journal. 1997; 74:680–9. [PubMed: 9557436]
48. Dannhauser A, van Staden AM, van der Ryst E, Nel M, Marais N, Erasmus E. Nutritional status of HIV-I seropositive patients in the Free State Province of South Africa: anthropometric and dietary profile. European Journal of Clinical Nutrition. 1999; 53:165–73. [PubMed: 10201796]
49. Wolmarans P, Seedat YK, Mayet FG, Joubert G, Wentzel E. Dietary intake of Indians living in the metropolitan area of Durban. Public Health Nutrition. 1999; 2:55–60. [PubMed: 10452732]
50. Faber M, Jogessar VB, Benade AJ. Nutritional status and dietary intake of children aged 2-5 years and their caregivers in a rural South African community. International Journal of Food Science and Nutrition. 2001; 52:401–11.
51. Nthangeni G, Steyn N, Alberts M, Steyn K, Levitt NS, Laubscher R, et al. Dietary intake and barriers to dietary compliance in black type 2 diabetic patients attending primary health care services. Public Health Nutrition. 2002; 5:329–38. [PubMed: 12020385]

52. Faber M. Complementary foods consumed by 6-12-month-old rural infants in South Africa are inadequate in micronutrients. Public Health Nutrition. 2005; 8:373–81. [PubMed: 15975182]
53. MacIntyre UE, Kruger HS, Venter CS, Vorster HH. Dietary intakes of an African population in different stages of transition in the North West Province, South Africa: the THUSA study. Nutrition Research. 2002; 22:239–56.
54. Jinabhai CC, Taylor M, Sullivan KR. Changing patterns of under- and over-nutrition in South African children - future risks of non-communicable diseases. Annals of Tropical Paediatrics. 2005; 25:3–15. [PubMed: 15814043]
55. Jinabhai CC, Taylor M, Sullivan KR. Implications of the prevalence of stunting, overweight and obesity amongst South African primary school children: a possible nutrition transition? European Journal of Clinical Nutrition. 2003; 57:358–65. [PubMed: 12571672]

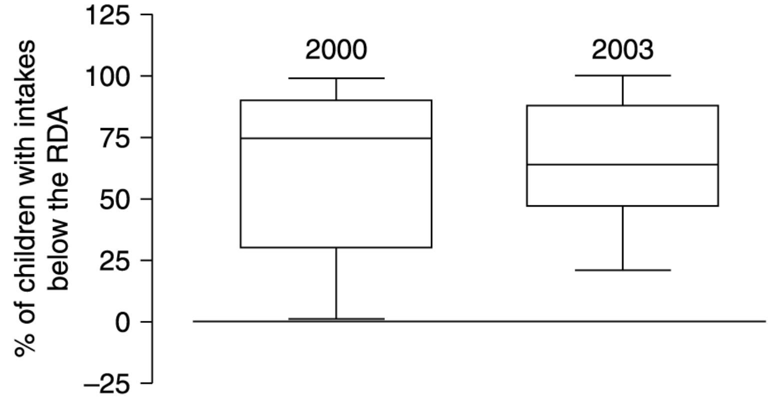

Fig. 1.

Box and whisper plots of limits, quartiles and medians of all nutrients according to the percentage of children with intakes below the recommended dietary allowance (RDA)

Europe PMC Funders Author Manuscripts

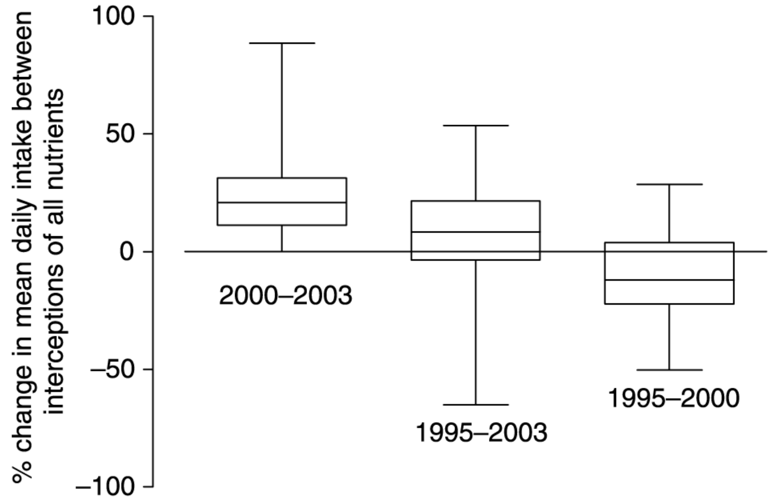

Fig. 2.

Box and whisper plots of limits, quartiles and medians of all nutrients as a percentage of change in intake between interceptions for the longitudinal group of 143 black urban children

Europe PMC Funders Author Manuscripts

Table 1

Mean daily (95% confidence intervals) energy and nutrient intakes for urban black South Africans (n = 143)

	RDA 7-10 years	2000	RDA 11-14 years	2003
Energy (kcal)	2000	1767 (1697.3, 1836.0)	2200	2127 (1994.0, 2260.0)
Protein (g)	28	56 (53.76, 58.25)	45	59 (55.21, 62.79)
Total fat (g)		51 (48.64, 53.36)		70 (62.87, 76.73)
Cholesterol (g)		173 (160.7, 185.3)		212 (188.5, 235.1)
Total carbohydrate (g)		279 (266.4, 290.6)		323 (304.3, 341.7)
Fibre (g)		22 (20.82, 23.38)		23 (20.70, 24.30)
Added sugar (g)		68 (62.46, 73.14)		102 (95.04, 109.74)
Calcium (g)	800	497 (462.5, 531.5)	1200	642 (585.0, 699.0)
Vitamin B_{12} (µg)	1.4	2.3 (2.12, 2.48)	2.0	2.8 (2.52, 3.08)
Iron (mg)	10	8.5 (8.12, 8.88)	12	10.2 (9.45, 10.95)
Magnesium (mg)	170	290 (274.3, 305.7)	270	318 (294.6, 341.4)
Phosphorus (mg)	800	956 (911.4, 1001.0)	1200	1082 (1006.0, 1158.0)
Potassium (mg)	1600, 2000	1695 (1621.3, 1768.7)	2000	2057 (1925.1, 2188.9)
Zinc (mg)	10	7.7 (7.36, 8.04)	12	8.2 (7.64, 8.76)
Copper (mg)	1.0, 2.0	1.1 (1.03, 1.17)	1.5	1.1 (1.02, 1.18)
Vitamin A (RE)	700	332 (305.4, 358.0)	800	620 (545.7, 694.3)
Thiamin (mg)	1.0	1.0 (0.95, 1.05)	1.0, 1.3	1.2 (1.12, 1.28)
Riboflavin (mg)	1.2	0.9 (0.83, 0.97)	1.5	1.2 (1.09, 1.32)
Nicotinic acid (mg)	13	12.7 (12.08, 13.32)	15	14.7 (13.59, 15.82
Vitamin B_6 (mg)	1.4	1.1 (1.03, 1.17)	1.4	1.6 (1.49, 1.72)
Folic acid (µg)	100	197 (187.2, 206.9)	150	242 (223.1, 260.9)
Ascorbic acid (mg)	45	35 (29.29, 39.91)	50	66 (58.28, 73.13)
Pantothenic acid (mg)	4.0, 5.0	2.8 (2.67, 2.93)	5.5	3.4 (3.15, 3.65)
Biotin (µg)	30	18.0 (16.92, 19.08)	65	20.3 (18.72, 21.82)
Vitamin E (mg)	7	7.9 (7.41, 8.39)	8	9.6 (8.80, 10.40)
Manganese (mg)	2.0, 3.0	3.6 (3.34, 3.86)	3.5	3.8 (3.46, 4.14)

RDA - recommended dietary allowance; RE - retinol equivalents.

Europe PMC Funders Author Manuscripts

Table 2

Percentage of individuals below the RDA

Nutrient	Year 2000	Year 2003
Energy	73	59
Protein	1	31
Calcium	90	93
Vitamin B12	16	38
Iron	71	74
Magnesium	12	48
Phosphorus	31	66
Potassium	78	50
Zinc	85	85
Copper	90	77
Vitamin A	98	78
Thiamin	54	58
Riboflavin	78	70
Nicotinic acid	57	62
Vitamin B6	76	100
Folic acid	4	21
Ascorbic acid	80	46
Pantothenic acid	98	91
Biotin	98	100
Vitamin E	42	43
Manganese	29	56

RDA - recommended dietary allowance.

Europe PMC Funders Author Manuscripts

Table 3

Nutrients by quartile according to the percentage of urban black children below the RDA (n = 143)

% below the RDA	Year 2000	Year 2003
0-25	Protein, vitamin B_{12}, magnesium, folic acid	Folic acid
26-50	Phosphorus, manganese, vitamin E	Protein, vitamin B_{12}, magnesium, potassium, ascorbic acid, vitamin E
51-75	Energy, iron, thiamin, nicotinic acid	Energy, iron, phosphorus, thiamin, riboflavin, nicotinic acid, manganese
>75	Calcium, potassium, zinc, copper, vitamin A, riboflavin, vitamin B_6, ascorbic acid, pantothenic acid, biotin	Calcium, zinc, copper, vitamin A, vitamin B_6, pantothenic acid, biotin

RDA - recommended dietary allowance.

Europe PMC Funders Author Manuscripts

Table 4

Percentage of change in daily mean intake of nutrients (95% confidence intervals) of urban black South African children (n = 143)

Nutrient	% change 2000-2003	% change 1995-2003	% change 1995-2000
Energy	20.37 (20.33, 20.44)	−2.74 (−2.78, −2.71)	−19.2 (−19.82, −18.59)
Protein	5.36 (5.13, 5.58)	0 (−0.22, 0.22)	−5.08 (−5.75, −4.42)
Fat	37.25 (36.88, 37.63)	−31.37 (−31.55, −31.20)	−50.29 (−50.82, −49.18)
Cholesterol	22.54 (22.36, 22.78)	−28.37 (−28.48, −28.27)	−41.55 (−46.49, −36.62)
Carbohydrate	15.77 (15.67, 15.87)	21.89 (21.78, 21.99)	4.94 (0.69, 9.18)
Fibre	4.55 (4.15, 4.94)	21.05 (20.58, 21.53)	19.46 (13.46, 25.46)
Added sugar	50.0 (0)	34.21 (33.98, 34.44)	−11.02 (−17.86, −4.19)
Calcium	29.18 (29.08, 29.27)	−4.89 (−4.96, −4.82)	−26.37 (−32.27, −20.47)
Vitamin B_{12}	21.74 (20.25, 23.23)	7.69 (6.36 - 9.03)	−11.54 (−18.15, −4.92)
Iron	20.0 (19.32, 20.68)	36.0 (35.2, 36.8)	13.33 (8.63, 18.03)
Magnesium	9.66 (9.55, 9.76)	10.42 (10.31, 10.53)	0.69 (−4.26, 5.65)
Phosphorus	13.18 (13.12, 13.24)	−1.19 (−1.24, −1.14)	−12.70 (−17.45, −7.94)
Potassium	21.36 (21.31, 21.4)	−6.5 (−6.53, −6.47)	−22.95 (−26.91, −19.00)
Zinc	6.49 (5.86, 7.12)	9.33 (8.67, 9.99)	2.67 (−1.68, 7.02)
Copper	0 (−1.71, 1,71)	10.0 (8.03, 11.97)	10.0 (4.45, 15.55)
Vitamin A	86.75 (86.56, 86.93)	4.91 (4.81, 5.00)	−43.82 (−49.27, −38.38)
Thiamin	20.0 (18.13, 21.87)	9.09 (7.38, 10.80)	−9.09 (−14.65, −3.53)
Riboflavin	33.33 (30.87, 35.79)	0 (−1.87, 1.87)	−25.0 (−34.04, −15.96)
Nicotinic acid	15.75 (15.20, 16.29)	25.0 (16.70, 33.30)	7.63 (1.46, 13.80)
Vitamin B_6	45.45 (43.44, 47.47)	14.28 (12.70, 15.87)	−21.43 (−26.87, −16.49)
Folic acid	22.84 (22.7, 22.99)	22.84 (22.68, 23.00)	0.15 (−9.77, 10.07)
Ascorbic acid	88.57 (88.06, 89.08)	53.49 (53.08, 53.90)	−20.28 (−32.82, −7.73)
Pantothenic acid	21.43 (20.26, 22.59)	−2.86 (−3.78, −1.93)	−20.0 (−24.17, −15.83)
Biotin	12.78 (12.33, 13.22)	−4.25 (−4.62, −3.87)	−15.09 (−20.16, −10.03)
Vitamin E	21.52 (20.78, 22.26)	−58.17 (−53.84, −52.50)	−61.46 (−72.75, −0.17)
Manganese	5.56 (4.49, 6.62)	35.71 (33.69, 37.74)	28.75 (19.67, 37.47)