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Determining appropriate nutritional interventions for South African children living in informal urban settlements

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Rapid urbanisation in South Africa has led to the creation of informal shack settlements where the health status of children is in jeopardy; it needs to be monitored so that appropriate intervention strategies can be formulated.

Accordingly, the nutritional status of 190 children (3 - 6 years of age) living in Besters, a typical urban shack settlement north of Durban, was assessed anthropometrically. In addition the following biochemical values were determined: vitamins A and E, calcium, magnesium, phosphorus, albumin, haemoglobin, serum iron and ferritin and percentage of transferrin saturation.

Malnutrition was evident in 13% of the children who were underweight (below the National Center for Health Statistics (NCHS) third weight-for-age percentile) and 27% who were stunted (below the NCHS third height-for-age percentile). Concentrations of albumin, calcium, magnesium, phosphorus and vitamin E were close to normal, with no more than 10% of the sample having values outside the normal range. However, 44% of the children had low serum retinol levels (< 20 μg/dl) and 21% of the children had anaemia (haemoglobin < 11 μg/dl). Significant positive correlations were found between serum retinol and all biochemical indicators of iron status except serum ferritin.

This study highlights the fact that nutrient deficiencies are interrelated, particularly protein energy malnutrition and poor vitamin A and iron status. A broad multifaceted comprehensive health intervention programme is therefore required.

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Urbanisation in South Africa is occurring at an unprecedented rate, and informal shack settlements have mushroomed on the outskirts of cities. The health status of children living in such conditions is presumably being jeopardised.[1]

Selective primary health initiatives such as oral rehydration therapy, breast-feeding and immunisation have been proven effective in addressing diarrhoea and some common childhood infections.[2] However malnutrition, especially protein energy malnutrition (PEM), remains an intractable problem, even when other diseases have been successfully controlled. It would appear that only wide-ranging, integrated and comprehensive health and social interventions can improve the nutritional status of children.[3,4] A reduction in the incidence of PEM thus remains a touchstone of effective intervention programmes, although recently international concern has also focused on micronutrient deficiencies.[5,6]

While some principles of nutrition intervention have a universal application, each country or region needs to be considered individually; the socio-economic and cultural conditions as well as the exact extent of nutritional deficiencies need to be well documented before any specific intervention strategies can be formulated. The object of this study was to assess the nutritional status of those most at risk for nutritional deficiencies, viz. preschool children 3 - 6 years of age. This information is necessary for the formulation of a specific intervention programme and, in addition, will be needed for the adequate assessment of the impact of any intervention strategy implemented.

Subjects and methods

During November 1991, the nutritional status of preschool children (3 - 6 years of age) living in Besters, a typical urban shack settlement in Natal/KwaZulu, was assessed. Being a typical urban shack settlement, Besters has the typical poor socio-economic profile of such settlements. The majority of houses (77%) are constructed of wattle and daub. There is no running water; water is drawn from a communal kiosk in the majority of cases. There is no refuse removal service and refuse is usually dumped on the ground. The mean monthly household income is R513,25 and the mean monthly per capita income R118,70.

Besters has a population of approximately 16 000, with 3 200 households in 11 units. A sample of 360 households was randomly selected by means of a stratified random sampling technique[7] that allowed for a 5% sampling error. This produced a sample of 182 children between the ages of 3 years and 6 years. To allow for the fact that approximately 5% of the children or their parents would be reluctant to take part in the study, the sample size was set at 192 children to ensure a final sample of 182. If more than 1 child in a particular household was eligible for entry into the study only 1 child was randomly selected. Children outside the stipulated age range and those not normally resident in the target area were not eligible for the study.

Community-based facilitators visited the households and explained the importance of assessing children's nutritional status and the procedure which would be carried out. Thereafter, written informed consent from the parent or guardian of the child was obtained.

All children were brought to the community's newly constructed clinic on a pre-arranged date. Each child was weighed without shoes to the nearest 0,5 kg on a bathroom scale calibrated with a known weight. Height was measured to the nearest 0,5 cm by means of an anthropometer comprising a wooden platform with a scale of 2 metres and a sliding head piece. Weight-for-age (WA), height-for-age (HA) and weight-for-height (WH) percentiles were determined from National Center for Health Statistics (NCHS) tables.[8] Standard deviation (SD) scores were calculated for each child from the NCHS tables. A SD WA score of 2,00 or –2,00 means that the child is 2 SD above or below the median WA/HA/WH respectively.

Blood samples were taken by antecubital venepuncture. These samples were used to determine haematological factors and various micronutrient levels, viz. vitamins A and E, calcium, magnesium, phosphorus, albumin, haemoglobin, serum iron, ferritin and percentage transferrin saturation. The sera were kept frozen at –20°C until they were analysed. All samples were analysed within 3 months of collection.

Serum samples for vitamin A and E analysis were posted on dry ice to Cape Town where the analysis was performed by the Department of Human Nutrition, University of Stellenbosch, with a modified version of the method of Catignani and Bieri.[9] During processing and analysis precautions were taken to protect the serum from light as vitamin A is sensitive to photodestruction. Haematological factors were determined in the routine Haematology Laboratory attached to King Edward VIII Hospital, Durban. Plasma calcium, magnesium and phosphorus levels were measured by the standard technique on a Beckman Synchron CX5. Plasma albumin levels were measured by the bromocresol purple method. Serum ferritin levels were measured by radio-immunoassay (Amersham).

Anaemia was defined as a haemoglobin level < 11 g/dl according to the World Health Organisation criteria for children up to 6 years of age at sea level. Serum ferritin levels < 10 µg/dl and transferrin saturation values <10% were regarded as indicative of exhausted iron stores.[10,11]

The normal reference values for calcium, magnesium, phosphorus and albumin were taken from a South African paediatric reference population[12] and are as follows: calcium 2,25 - 2,62 mmol/l; magnesium 0,75 - 1,05 mmol/l; phosphorus 1,30 - 1,80 mmol/l; albumin > 35 g/l. The generally accepted cut-off values for inadequate nutriture of vitamins A and E are 20 µg/dl and 5 mg/l respectively.[13]

Descriptive statistics were used and Pearson correlation coefficients employed to examine the relationship between all the variables considered. The software used for the computerised analysis of results was the Statistical Analysis System (SAS), release 6,03 edition, 1988 (SAS Institute, Cary, NC).

Results

Of the 192 children randomly selected for inclusion in this nutritional study, 2 were excluded (1 was mentally retarded and the other was very ill with a high fever). Demographic data on the remaining 190 children are presented in Table I. Five of the 190 children refused to undergo venipuncture, and in 8 children a blood sample was not obtained at the first attempt and no repeat attempts were made. Not all the children had sufficient unclotted blood and/or serum for all the biochemical investigations — the numbers sampled for each investigation are shown in Table II.

Table I. Demographic profile of 190 subjects

	No.	%
Age (yrs)		
3	47	25
4	61	32
5	40	21
6	42	22
Sex		
M	91	48
F	99	52
Anthropometric measurements		
Weight/age < 3rd centile*	24	13
Height/age < 3rd centile	51	27
Weight/height < 3rd centile	7	4

* NCHS standard.

The mean values for all biochemical parameters are shown in Table II. Concentrations of albumin, vitamin E, calcium, magnesium and phosphorus were close to normal, with no more than 10% of the sample having values outside the normal range. The micronutrient concentrations which were out of the normal range were vitamin A and iron. The mean serum retinol level for the whole population was 20,8 ± 7,4 µg/dl (mean ± SD). Nine children (5%) had vitamin A deficiency (serum retinol levels < 10 µg/dl) and 75 children (44%) had low levels of serum retinol, i.e. < 20 µg/dl.[14] Twenty-one per cent of the children had anaemia as classified by haemoglobin levels < 11 µg/dl. Parameters which confirm that the anaemia could be due to iron deficiency are mean corpuscular volume (MCV), serum iron and percentage transferrin saturation, all of which were low in a relatively large percentage of the population. In addition there were positive correlations between these parameters; MCV correlated with transferrin saturation (r = 0,25; P < 0,01) and with haemoglobin (r = 0,47; P < 0,0001). Haemoglobin correlated with transferrin saturation (r = 0,31; P < 0,001). However, a much smaller proportion of the children had low serum ferritin levels.

Table II. Blood and serum variables of Besters children

	No.	Mean ± SD	Normal threshold	% below threshold
Calcium (mmol/l)	95	2,47 ± 0,09	≥ 2,25	1
Magnesium (mmol/l)	95	0,87 ± 0,06	≥ 0,75	1
Phosphorus (mmol/l)	95	1,45 ± 0,19	≥ 1,3	10
Albumin (g/l)	95	39,8 ± 4,0	≥ 35	6
Serum retinol (µg/dl)	169	20,8 ± 7,4	≥ 20	44
Vitamin E (mg/l)	169	8,1 ± 2,3	≥ 5	5
Haemoglobin (g/dl)	168	11,7 ± 1,2	≥ 11	21
Mean corpuscular volume (fl)	168	80,5 ± 4,9	≥ 77	14
Serum ferritin (µg/dl)	138	30,7 ± 20,4	≥ 10	8
Serum iron (µmol/l)	137	11,2 ± 5,6	≥ 9	36
% transferrin saturation	114	16,6 ± 8,9	≥ 10	27

Table III. Coefficient of correlation (r) between biochemical and anthropometric parameters

	1	2	3	4	5	6	7	8	9	10
1. Haemoglobin										
2. Mean cell volume	0,47§									
3. Haemotocrit	0,96§	0,42§								
4. Serum ferritin	–0,07	0,12	–0,02							
5. Transferrin saturation	0,31‡	0,25†	0,30‡	0,01						
6. Serum iron	0,30‡	0,21†	0,28‡	–0,07	0,96§					
7. Serum retinol	0,25‡	0,18*	0,21†	–0,09	0,34‡	0,32‡				
8. Vitamin E	0,11	–0,01	0,10	–0,08	0,25†	0,26†	0,28‡			
9. SD WA	0,01	–0,03	0,03	0,17	0,19	0,15	0,13	–0,12		
10. SD HA	0,00	–0,06	0,00	0,14	0,10	0,13	0,07	0,01	0,65§	
11. SD WH	0,02	0,02	0,03	0,08	0,14	0,06	0,14	–0,15	0,68§	–0,09

* $P < 0,05$.
† $P < 0,01$.
‡ $P \leq 0,001$.
§ $P = 0,0001$.

The interrelationships between the different variables investigated are shown in Table III. There was a significant positive correlation between serum retinol and all the biochemical indicators of iron status except for serum ferritin.

Stool examination of a subsample of 75 children showed that 91% had parasites; the majority of these had multiple parasites, the most common of which were ascaris (59% frequency), trichuris (61% frequency), *Escherichia coli* (20% frequency) and *Giardia lamblia* (31% frequency).

Discussion

Acute malnutrition (< 3rd NCHS WA percentile) was found in 12,6% of the children, although acute severe malnutrition was not a problem, with only 3,6% below the 3rd NCHS WH percentile. However the figure of 26,8% below the 3rd NCHS HA percentile indicates fairly high levels of chronic malnutrition. This finding is not surprising given that stunting is an indicator of poor socio-economic and environmental conditions. The consequences of unchecked rapid urbanisation are, in fact, the establishment of informal settlements with poor socio-economic and environmental conditions. What is noteworthy and of concern is that the percentage of children with acute malnutrition (12,6%) is higher than the 5,3% found in a neighbouring informal settlement in 1984;[15] this seems to suggest that the situation in informal settlements is deteriorating. The percentages of underweight and wasted preschool children in our study are similar to those currently found in other informal settlements in South Africa. In a Cape Town squatter settlement,[16] they were 13,7% and 1,0% respectively and in a Durban informal settlement[17] 14% and 0% respectively. Stunting was also much more frequent. These findings are in keeping with the national data for South Africa which reveal a high level of chronic malnutrition among black children. Current understanding of the causes of PEM suggests that it is the end result of a number of macro-economic, social and political causes. The proximate causes however are inadequate dietary intake and frequent infections.[18]

The results reveal a poor vitamin A status with 44% of the population having levels below 20 µg/dl. Although none of the children had obvious clinical signs of vitamin A deficiency, the large percentage with low serum retinol levels suggests that a large proportion of the population has marginal vitamin A deficiency that places them at risk for respiratory and diarrhoeal infections.[19] It is likely that this poor vitamin A status is partly explained by inadequate dietary intake and partly by the frequent infections experienced by the children. The national data on the prevalence of vitamin A deficiency are sparse and at present suggest that it is prevalent in some rural populations, and in association with PEM and severe measles.

The iron status of the children was poor with relatively large numbers having low haemoglobin, MCV, serum iron and percentage transferrin values. Given the prevalence of PEM and single nutrient deficiencies it is likely that one of the causes of poor iron status is inadequate iron in the diet. This poor iron status could, however, be exacerbated by factors other than nutritional ones such as a high prevalence of parasites, especially trichuris. It was surprising that no children had hookworm infestation (the parasite more commonly associated with iron deficiencies) even although it is prevalent in Natal/KwaZulu.

Several previous epidemiological studies have indicated that vitamin A deficiency and anaemia often coexist and that there are significant associations between serum retinol and biochemical indicators of iron status.[20-22] Our results seem to confirm these findings and imply that the relatively high prevalence of anaemia could also be vitamin A-related. The exact mechanism by which vitamin A might influence iron status is not clear, although vitamin A seems to be essential for the differentiation of red blood cells; this is suggested by the association between retinol and haematocrit. It is also likely that as vitamin A deficiency increases susceptibility to infections, it could also affect haematopoiesis. This association is of great public health significance because vitamin A and iron deficiencies are two of the three important micronutrient deficiencies affecting children of developing nations; such data highlight the importance of ensuring that children have an adequate vitamin A status.

This study highlights the interrelationship between some nutrient deficiencies and emphasises the fact that they are interwoven with other factors into a seamless fabric of deprivation. Attempts at correcting, in particular, PEM and poor iron and vitamin A status should take this into account and should therefore be located within a broad multifaceted comprehensive health intervention programme.[23]

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