NUTRITIONAL STATUS AND DENTAL CARIES IN A LARGE SAMPLE OF 4- AND 5-YEAR-OLD SOUTH AFRICAN CHILDREN

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Background. Evidence from studies involving small samples of children in Africa, India and South America suggests a higher dental caries rate in malnourished children. A comparison was done to evaluate wasting and stunting and their association with dental caries in four samples of South African children.

Design. Cross-sectional study based on random sampling of birth records of two age bands.

Methods. A total of 2 728 4- and 5-year-old South African children from one rural community and three urban communities were examined for nutritional status and dental caries.

Results. In the total sample prevalences of wasting were mild (28%), moderate (4%) and severe (2%). For stunting the prevalences were mild (13%), moderate (3%) and severe (1%). For both conditions rural children showed higher proportions than the other groups. Statistical analysis showed statistically significant differences for wasting and stunting between the study groups. No significant association was found between the prevalence of caries and stunting or wasting, but an association was noted between wasting and decayed, missing and filled (dmf) surfaces ($P = 0.003$).

Conclusions. In the series of children studied, nutritional status was not found to be clinically relevant to dental caries prevalence and experience.

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Alvarez and Navia[1] reviewed the interaction between nutritional status, tooth eruption and dental caries and highlighted the difficulty of demonstrating a clear correlation between malnutrition and increased dental caries, in contrast to the clear effects demonstrated in animal experiments. They showed that delayed tooth eruption was associated with malnutrition in industrialised as well as in developing countries. The authors provided a hypothetical caries prevalence versus age curve that might be seen as a cross-sectional survey of 6- to 15-year-old children in a population in which normal growth and mild-to-moderate stunting of growth coexist. They postulated that due to delayed eruption of the permanent teeth, more caries would be seen in the primary dentition at a particular age in malnourished children, and less in the permanent dentition, when compared with their well-nourished counterparts. Evidence to support this concept has come from cross-sectional surveys undertaken on Peruvian children[2,3] as well as from a longitudinal survey of the primary teeth, also done on Peruvian children.[4] The most recent study in the latter group[5] has confirmed the higher caries rate in malnourished children.

In India, salivary flow was reported to be reduced among malnourished children,[6] probably from alteration in the salivary glands due to chronic protein energy malnutrition (PEM), an effect shown in animal studies.[7] Children with this reduced salivary flow had decreased salivary buffer capacity and increased dental caries.

In Africa, 1-5-year-old children classified clinically as malnourished had more caries than those regarded as normally nourished;[8] however, among 10-12-year-old children those below and above the 5th percentile of weight for age had similar caries rates.[9]

Of the studies reported so far, sample sizes have been small, or when moderately large, they have been spread over a wide age range. This paper reports findings on the relationship between nutritional status and caries in a large series of South African children within a narrow age band.

METHODS

The sample studied consisted of 2 728 children aged 4 or 5 years. One rural group was from the Gelukspan district in North West, approximately 350 km west of Johannesburg, an area with a fluoride concentration in the drinking water of 0.13 - 0.22 ppm.[10] In Gauteng urban groups came from three areas, namely Soweto, Lenasia and Johannesburg. The water supply for these three groups was the same and contained 0.20 - 0.33 ppm fluoride.[11] The four groups came from areas that under apartheid legislation had corresponded with residential areas for blacks (Gelukspan, Soweto), Indians (Lenasia) and whites (Johannesburg). In the current study the areas were used as proxy indicators of broad social conditions.

Following clearance by the Committee for Research on

Human Subjects of the University of the Witwatersrand, random samples of children were drawn from birth records at well-child clinics (where all birth records were stored), the target being 700 for each of the four groups. Gender sub-samples were approximately equal in each group.

Oral examinations were carried out by calibrated dentists[12] in good natural light using plane mirrors, probes (explorers) and World Health Organisation (WHO) caries diagnosis criteria.[13] Dental caries was diagnosed when there was clinically detectable loss of tooth substance and when such loss had been treated with fillings or extraction. The sum of decayed, missing and filled (dmf) tooth surfaces for an individual's primary teeth constituted the dmfs score, with a maximum possible score of 88. The height of the children, erect and barefoot, was measured with a height stick to the nearest 0.5 cm, and weight was measured using a bathroom-type scale to the nearest 0.5 kg. For calibration, this scale was checked at frequent intervals against an accurate beam balance laboratory scale (Detecto Personal Weigher, Detecto Scales Inc.; Brooklyn NY, USA).

For stunting (chronic malnutrition) and wasting (acute malnutrition) the classification of Waterlow[14-16] was used together with the National Center for Health Statistics (NCHS) tables.[17] Using a percentage of the NCHS median (50th percentile) the classification was as follows. For stunting, the height-for-age ranges were: normal (≥ 95% of the median), mild (≥ 90% - < 95%), moderate (≥ 85% - < 90%) and severe (< 85%). In the case of wasting, weight-for-height groupings were: over-nutrition (≥ 110%), normal (≥ 90% - < 110%), mild (≥ 80% - < 90%), moderate (≥ 70% - < 80%) and severe (< 70%).

For a within-study comparison using a common scale and common median, the median height and weight were determined for the combined study sample. Each individual's height and weight were then expressed as a percentage of these sample medians.

The data for both age groups were pooled for analysis using the Statistical Analysis System (SAS).[18] In analysing the stunting and wasting categories, the chi-square test was used and Bonferroni's significance levels[18] were included when pairwise comparisons of study groups were made. The critical levels of statistical significance were set at $P < 0.05$ for the simultaneous comparison of all groups and at $P < 0.01$ for the six pairwise comparisons.[19] The individual's percentage of median height and percentage of median weight were analysed using the general linear model method. For the association between dental caries, stunting and wasting, the Catmod Procedure was used for presence or absence of dental caries, and the Kruskal-Wallis non-parametric test was used for dmfs scores. The null hypotheses set were: (*i*) that malnutrition is not different in the four study groups; and (*ii*) that malnutrition is not associated with dental caries.

Results

Detailed anthropometric results for each age, gender and group have been provided in a reference data base[10] that is available from the authors.

The frequency of wasting in each study group is shown in Table I. Over-nutrition was seen in almost 15% of the Johannesburg sample and in 9% of the Soweto children but was uncommon in the other two groups studied. Mild wasting was seen in 28% of the total sample. It was higher among Lenasia (42%) and Gelukspan (43%) children, with the lowest

Table I. Frequency of wasting and stunting in 1984 among 2 728 4- and 5-year-old South African children subdivided by study group

		Wasting									
		Over-nutrition		Normal		Mild		Moderate		Severe	
Group	N	N	%	N	%	N	%	N	%	N	%
Gelukspan	665	14	2.1	311	46.8	286	43.0	48	7.2	*	
Soweto	752	69	9.2	556	73.9	117	15.6	*		*	
Lenasia	587	24	4.1	260	44.3	246	41.9	45	7.7	12	2.0
Johannesburg	708	104	14.7	469	66.2	123	17.4	*		*	
Total	2 712	211	7.8	1 596	58.9	772	28.5	108	4.0	25	0.9

		Stunting							
		Normal		Mild		Moderate		Severe	
	N	N	%	N	%	N	%	N	%
Gelukspan	668	420	62.9	171	25.6	61	9.1	16	2.4
Soweto	755	645	85.4	87	11.5	17	2.3	*	
Lenasia	574	504	87.8	59	10.3	10	1.7	*	
Johannesburg	708	656	92.7	42	5.9	*		*	
Total	2 705	2 225	82.3	359	13.3	91	3.4	30	1.1

* $N < 10$.

frequency being seen in the Soweto group (16%). Moderate wasting was present in 7 - 8% of Lenasia and Gelukspan children compared with 1% in the other groups. Severe wasting was uncommon in all of the groups, with the highest frequency occurring in the Lenasia children (2%).

Stunting was uncommon (Table I); only 18% of the children showed some degree of stunting, most of which was mild. Within the study groups, stunting was most frequent among the Gelukspan and Soweto groups.

Chi-square tests for overall differences in the frequency distributions of wasting and stunting among the four study groups revealed highly significant differences among them for all groupings. When the classifications of wasting and stunting were combined, a pattern similar to wasting alone was seen. In general, Soweto and Johannesburg children's results were similar.

When the within-study comparisons were done with the general linear models analysis for percentage of median weight, the study group showed a highly significant effect ($F = 232.98$, $P < 0.001$) as did percentage of the median height ($F = 186.97$, $P < 0.0001$). Tukey's multiple comparison test showed that the Johannesburg and Soweto children differed significantly from the Lenasia and Gelukspan children for percentage of median height, while for percentage of median weight all study groups differed significantly (data available from authors).

The percentage of children with caries and mean and standard deviation of dmfs scores were cross-tabulated by wasting and stunting (Table II) to look for trends. Only groups containing at least 10 children were included. No consistent trends were seen within the study groups, but when the results for all the groups in the study were combined a clear but statistically not significant trend of increasing caries prevalence with increasing wasting was seen. The same trend was noted for dmfs scores, but this was statistically significant ($\chi^2 = 16.24$, $P = 0.003$). For stunting no clear trends were seen. When dmfs scores were analysed, the Kruskal-Wallis test showed a weakly significant effect for stunting ($\chi^2 = 8.80$, $P = 0.03$) but a more strongly significant effect for wasting ($\chi^2 = 16.24$, $P = 0.003$).

DISCUSSION

In nutrition studies choice of malnutrition definition is important for comparison of the findings of different researchers. There is no one accepted definition. Waterlow[14] clearly motivated for the general requirements of a classification system. We used Waterlow's classification because it is practical, sound, and has been used by other workers such as Alvarez and colleagues.[1-5]

Comparison of wasting and stunting in our study groups with groups elsewhere was not the main purpose of the current article. However, to give some perspective a recent African study by Aldana and Piechulek,[20] which examined children aged 0 - 59 months in Cameroon, found that prevalences of wasting were 6% for rural areas and 4% for urban areas. Stunting was found to be 22% in rural areas and 15% in urban areas, all of which figures are considerably lower than those in our South African samples.

Among South American children Alvarez *et al.*[3] have shown clearly that when dmft teeth are plotted against age, a bell-shaped curve results that shifts to the right by 2.5 years in

Table II. Percentage prevalence of individuals with caries, mean dmfs and standard deviation (SD) among 2 728 South African children examined in 1984, subdivided into study group and wasting or stunting group

	Over-nutrition			Normal			Wasting: Mild			Wasting: Moderate			Wasting: Severe		
Group	%	Mean dmfs	SD	%	Mean dmfs	SD	%	Mean dmfs	SD	%	Mean dmfs	SD	%	Mean dmfs	SD
Gelukspan	35.7	5.0	11.8	51.8	3.3	5.4	52.6	3.8	7.8	42.9	3.2	9.2	*		
Soweto	68.1	4.9	7.2	70.1	6.8	10.1	75.2	7.8	11.2	*			*		
Lenasia	83.3	9.9	8.3	83.0	12.5	16.3	85.8	12.4	13.5	77.8	11.0	15.2	83.3	19.6	22.4
Johannesburg	60.6	4.3	6.6	54.4	5.7	10.1	62.6	7.2	11.4	*			*		
Total	65.8	5.3	7.3	68.2	7.7	11.9	71.7	8.7	12.5	75.0	9.2	15.7	81.8	13.5	19.4

	Normal			Stunting: Mild			Stunting: Moderate			Stunting: Severe		
	%	Mean dmfs	SD	%	Mean dmfs	SD	%	Mean dmfs	SD	%	Mean dmfs	SD
Gelukspan	51.0	3.6	6.7	57.6	3.5	6.3	41.9	4.0	10.9	37.5	3.4	6.8
Soweto	71.6	6.7	10.0	64.4	7.2	9.9	76.5	8.6	12.0	*		
Lenasia	84.1	11.8	14.4	88.1	18.5	17.6	70.0	7.2	8.4	*		
Johannesburg	56.7	5.9	10.3	59.5	5.1	9.8	*			*		
Total	69.8	7.9	11.9	71.0	7.6	11.5	53.5	7.2	14.4	66.7	5.6	7.1

* $N < 10$.

malnourished groups compared with normal children, a statistically significant shift. This shift was associated with a delay in both the eruption and exfoliation of the primary teeth in malnourished children. Peak caries activity was significantly higher in wasted and stunted-wasted children when compared with normal controls. The authors concluded that malnutrition delayed tooth development, affected the age distribution of dental caries and resulted in increased caries experience in the primary teeth. Wasting, and stunting as well as wasting, were associated with a greater delay than stunting alone, suggesting that acute malnutrition (i.e. low weight for height) has a more pronounced effect on tooth exfoliation than chronic malnutrition (i.e. low height for age). Alvarez and colleagues[1-4] concluded that significant changes in the age distribution of dental caries in the primary teeth have important implications for epidemiological studies of dental caries. Firstly, comparisons of age-adjusted dental caries data between different countries or between different regions within a country cannot be made without the nutritional factor (i.e. skeletal growth) being taken into account. Secondly, infected carious molars stayed 2 or 3 additional years in the oral cavities of children with malnutrition at an age when most of the permanent teeth emerge (8 - 11 years), particularly the first permanent molar. This may increase the level of cariogenic bacteria in the mouth, and thereby increase the risk of caries development in the permanent dentition. A question that they consider remains unanswered is whether malnutrition in children leads to an increased caries experience.

Extensive animal experimentation has shown that protein-calorie malnutrition increases the caries rate in rats fed a moderately cariogenic diet.[21] It is likely that the effect of nutritional status on the timing of tooth eruption and caries development described above has been an important confounder that has prevented epidemiologists and clinicians from observing a clear-cut effect of malnutrition on caries experience in children.

Not all delay in permanent tooth eruption is nutritional; there is also a genetic influence. For example, in studies in our communities we have shown that permanent teeth erupt 3.5 - 7 months later among South Africa Indian children compared with their urban black counterparts.[22] We do not know if this delay in eruption has influenced the caries rates among South African children.

In India, Johansson *et al.*[6] studied salivary flow and dental caries in 8 - 12-year-old children suffering from chronic malnutrition as defined by weight-for-age ratios.[23] They found that 7% were severely, 25% moderately, and 38% mildly stunted, whereas 30% were of normal height for age according to Indian anthropometric standards.[24] Thirty-four children with severe-to-moderate PEM were selected for the study, and were compared with normal weight-for-age children from the same sample, as well as with well-nourished Swedish children. Stimulated saliva secretion rate decreased as malnutrition increased. The Swedish children had a significantly higher secretion rate of saliva than the age-matched malnourished Indian groups. Chronic malnutrition did not affect unstimulated secretion rate; however, the well-nourished Swedish children had a much lower buffer capacity than all four of the Indian PEM groups. The average amount of sucrose consumed per day was low. The Johannson study[6] showed a significant correlation between degree of chronic malnutrition and impairment of chewing-stimulated saliva secretion; furthermore secretion rate and buffer capacity were inversely correlated with malnutrition and dental caries. Diet may have influenced the secretion rates and possibly the immune system.

In another study done on our sample, black children were found to secrete saliva at approximately twice the rate of the white and Indian children.[10] Re-examination of those data according to wasting and stunting criteria showed a slight reduction in secretion rate of saliva which was weakly significant due to wasting ($N = 2\ 691$, $F = 3.29$, $P = 0.01$) and stunting ($N = 2\ 683$, $F = 3.04$, $P = 0.03$). No relationship between salivary secretion rate and dental caries was seen in our sample.

Walker *et al.*[9] concluded that a prejudicial effect of malnutrition on caries seen in 11-12-year-olds appears to concern principally the primary teeth. In their study, which was undertaken on a low-caries group of black schoolchildren, no disadvantage to the permanent teeth was apparent in the slower-growing moiety compared with the normal children.

The message of the current study is clear — a significant association was found between wasting and dmfs scores but not between stunting and dmfs scores. The strengths of the current study were the large sample size and the inclusion of groups known to vary in caries rate and degree of malnutrition. This conclusion differs from the work of Alvarez and colleagues[1-3,5] and that of Johannson *et al.*[6] in other countries. It is possible that confounding variables not considered in any of the studies are responsible for the differences between them.

This study report is the final one in a series dating from 1991 using data collected in 1984. The massive data set, which took almost 6 years to code, to store in a computer and to 'clean', is on file for comparison with data collected some 10 years later, in the same urban areas, as part of the Birth-to-Ten study.

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