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Risk factors for malnutrition in Brazilian children: the role of social and environmental variables

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The article reports the effects of several socioeconomic and environmental indicators on the nutritional status (stunting, underweight, and wasting) of a sample of 802 children aged 12-35.9 months in urban and rural areas of southern Brazil. Of the social variables studied, family income and father's education level were the two risk factors that showed the strongest associations with nutritional status. The mother's education level, employment status of the head of the family, number of siblings, and family's ethnic background also showed some degree of association, but these were less significant when family income was included in the analysis. Environmental variables, particularly the type of housing, degree of crowding, and type of sewage disposal, were also strongly associated with malnutrition. The effects of having access to piped or treated water were only apparent on stunting and wasting.

Protein-energy malnutrition is one of the most important global health problems and affects large numbers of children in developing countries (*1*, *2*). The influence of socioeconomic status on protein-energy malnutrition in children has been well documented (*3*), and some indicators identified include level of education of the parents (usually of the mother), occupation of the head of the household, ethnic origin of the family, land availability, and family income, as well as related indicators such as family size and place of residence. However, these variables are strongly associated among themselves and their relative importance has not received sufficient attention. Accordingly, interventions have often been proposed that may not be directed at the central risk factors of protein-energy malnutrition, but rather at risk markers or variables that are associated non-causally with poor nutritional status.

In contrast, there have been only a few studies of the effects of environmental variables on nutritional status. Infections contribute to childhood malnutrition not only through their adverse metabolic effects — including nitrogen loss — but also by reducing appetite, by affecting absorption, and by accelerating the intestinal transit of food (*4-8*). Episodes of diarrhoea are particularly responsible for growth deficiencies (*8-10*). In Mata's words, "the usual effects of the interaction of infection and deficient diet are weanling diarrhoea and repetitive acute respiratory disease, frequent weight loss, increased case fatality, and growth retardation" (*9*).

It is well known that, by impairing both humoral and cellular defences, poor nutritional status in young children diminishes their capacity to resist the consequences of infection (*4*, *6*). While it is not clear whether malnutrition actually increases susceptibility to infection, it is agreed that in malnourished children infections often follow a protracted course (*7*).

Since many environmental risk factors have been implicated in the transmission of infectious diseases, a few studies have attempted to relate these factors directly to the nutritional status of children. For example, in northern Nigeria, it has been reported that children aged 3-48 months living in households with a scanty, unprotected water supply exhibited a higher prevalence of wasting and underweight, but not of stunting, than children with adequate supplies of protected water (*11*). In Lebanon it was found that children aged 8-48 months who were "failing to thrive" were less likely than well-nourished controls to come from households with 3 or more rooms, with toilet facilities and piped water inside the home, as

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well as a bathroom and kitchen (*12*). Furthermore, in a case-control study in Jamaica, it was established that boys who had been hospitalized with marasmus or kwashiorkor during their first 2 years of life were more likely to come from poorly built, more overcrowded houses, with fewer furnishings and appliances, than those of controls (*13*). However, a problem associated with all such studies is that socioeconomic status may act as a confounding variable, since environmental factors are also indicators of wealth.

In the survey described here, associations were sought between several socioeconomic and environmental factors and the nutritional status of a population-based sample of young children living in urban and rural areas of southern Brazil. Specifically, we attempted to identify those indicators whose effects were still significant after family incomes had been taken into consideration.

MATERIALS AND METHODS

The study was carried out in the state of Rio Grande do Sul, one of the most developed agricultural areas of Brazil, where the birth rate and mortality are low compared to the rest of the country (*14*, *15*). The study was part of a survey to estimate the prevalence of malnutrition in children aged 12-35.9 months in two neighbouring districts (Alto Taquari and Campos de Vacaria), each having populations of approximately 140 000. These districts were selected because one had relatively low and the other had relatively high levels of infant and childhood mortality (infant mortality rates of about 20 and 60 per thousand, respectively). The survey was carried out in July and August 1982, and approximately 57% of the population in the two districts lived in rural areas.

Sampling

Five municipalities were selected, with probability proportional to size with replacement, in each of the two districts. Ten clusters—defined from detailed maps of census tracts—of 45 households were then randomly selected in each municipality, drawing from urban as well as rural areas. We attempted to interview all children aged 12-35.9 months living in these clusters by visiting each household chosen. The sampling scheme ensured that each child in the district had an equal chance of being included. The sampling fractions for the two districts were 6.6% and 6.2%, respectively, which resulted in approximately 400 children in each district. In total, 837 children were identified, of whom 31 could not be contacted, while 4 refused to be interviewed. The remaining 802 children (375 girls and 427 boys) formed the study sample. Thirty-four percent of the children were first-born, 26% second, 14% third, and the remaining 26% were of birth order four or more. Maternal ages were concentrated between 20 and 34 years (76%), with 4% aged <20 and 20% aged ≥35 years. In 24 families, there were two children in the 12-35.9 months age range, and in such instances both children were included in the study.

Questionnaire

The child's mother (91% of interviews) or a close relative answered questions on demographic, environmental, and socioeconomic characteristics of the family, on eating habits, and on the frequency that health services were used. The 11 interviewers (6 male, 5 female) consisted of 3 community physicians and 8 senior medical students, all of whom received a week's training before starting the field work. Information on the following socioeconomic variables was obtained (the percentages of households with the given characteristic are shown in parentheses).

1. *Per capita monthly income*: divided into quintiles (0-25, 26-41, 42-60, 61-109, and 110-1500 US dollars), each containing approximately 160 children. Monetary income as well as an estimate of the value of home-grown produce were included.
2. *Employment status of the head of the family*: casual labour or unemployed (2.0%), retired (2.5%), employee (44.0%), self-employed (42.0%), or employer (9.5%).
3. *Sector of activity of the head of the family*: agriculture (41.0%), forestry (4.2%), industry (19.2%), commerce (10.2%), service industries (13.2%), transport (6.3%), or government service (5.9%).
4. *Number of siblings*: 0 (28.2%), 1 (30.7%), 2 (16.2%), 3 (9.1%), 4 or 5 (10.0%), and ≥6 (5.8%).
5. *No. of years father attended school*: 0 (10.2%), 1-3 years (18.8%), 4-5 years (43.5%), 6-11 years (16.6%), or ≥12 years (11.0%).
6. *No. of years mother attended school*: 0 (9.8%), 1-3 years (19.2%), 4-5 years (41.2%), 6-11 years (18.3%), or ≥12 years (11.5%).
7. *Father's literacy*: literate (88.4%), illiterate (11.6%).
8. *Mother's literacy*: literate (88.3%), illiterate (11.7%).
9. *Ethnic origin of the family*: Brazilian-Portuguese (including those of Portuguese descent but also mulattos) (38.5%), Brazilian-Italian (19.2%), Italian (39.5%), Brazilian-African or blacks (2.8%).

In addition, information on the following environmental variables was obtained:

10. *Availability of domestic piped water*: piped water available inside the house (69.6%), communally (6.7%), or not at all (23.8%).

11. *Source of the water consumed*: domestic water obtained from a public supply (treated water) (43.8%), from a well (19.0%), or from a spring or river (37.2%).

12. *Type of latrine*: households with flush toilet (49.1%), pit latrine (40.8%), or no latrine (10.2%).

13. *Type of building materials*: bricks or cement (16.0%), mixed wood and bricks (9.8%), wood (regular boards) (52.6%), and shacks (irregular boards and/or improvized materials such as metal sheets, cardboard, or mud) (21.6%).

14. *Persons per room used for sleeping*: 0–1.9 persons (35.4%), 2–2.9 persons (36.0%), 3–3.9 persons (15.9%), and ≥4 persons (12.7%).

Anthropometry

Each child was weighed with a calibrated Salter-type spring scale and measured with an AHRTAG (Appropriate Health Resources Technologies Action Group) baby-length measurer, according to standard methods (*16*). Duplicate "blind" tests to assess repeatability showed a mean between-observer variation of 0.02 kg for weighings and 0.47 cm for length measurements. No significant tendency towards biased measurements was identified in any of the field-workers. Anthropometric standards issued by the National Center for Health Statistics (NCHS) were used to classify the children's length for age, weight for age, and weight for length in terms of the number of standard deviations (*z*-scores) below or above the median of the reference population (*17, 18*).

Stunting (low length for age) was more frequent than wasting (low weight for length) in the study population, while the prevalence of underweight children (low weight for age) was moderate. In order to identify risk factors it was desirable to have similar numbers of children classified as "malnourished" according to each of these three indicators. The lower 10% of the sample children, chosen arbitrarily to provide approximately 80 children in each of the "malnourished" categories, in length for age, weight for age, and weight for length—in terms of the *z*-score obtained as described above—were therefore compared to the upper 90%. In terms of numbers of standard deviations below the median of the NCHS standards, the data for the lower 10% correspond to −2.18 for length for age, −1.46 for weight for age, and −0.89 for weight for length. The results of the statistical analysis described below remained virtually unchanged if the cut-offs of −2 standard deviations (for length for age and weight for age) and −1 standard deviation (for weight for length) below the median of the NCHS reference data were used.

Statistical analysis

Linear logistic regression is being increasingly used to study variables whose outcome can be dichotomous, e.g., "diseased" or "disease-free". This method estimates the odds ratios of disease associated with each level of exposure to a particular variable (*19*). However, a prerequisite of this type of analysis is that the frequency of disease in the general population during the study period is low, in order that the odds ratios are a good approximation of the true relative risks. In the present study the prevalence of "malnutrition" in some of the exposure categories was as high as 30%, and the odds ratios would therefore exaggerate the true relative risks. A regression model was therefore developed in which the outcome variable was defined as the proportion of malnourished children among those exposed to a given risk factor, divided by the proportion of malnourished children among the unexposed, i.e., the risk ratio or "relative risk". These proportions are directly estimable from the data collected in the survey since a representative sample of the entire population was covered. The risk ratios were calculated using maximum likelihood methods (*20*) by defining a regression model having a logarithmic link and binomial error.[a]

To facilitate interpretation of the results, the risk ratios were converted into prevalences of malnutrition by multiplying them by the prevalence in the baseline category. The effect of each explanatory variable was assessed after the results had been adjusted for the district of residence, which makes allowance for the sampling scheme used. The level of family income (divided into quintiles) was also included in the model to verify whether the associations between other socioeconomic factors and nutritional status were still significant after testing for the possible confounding effect of income. The influence of these variables was assessed by including them in the model and performing a likelihood ratio test (*19*).

The data obtained were analysed by two-tailed tests, but one-tailed tests for trend were performed when it was reasonable to assume that the association was in a certain direction. Second- and third-order interactions between variables were tested at the $P = 0.01$ level.

Missing data accounted for less than 2% of the observations for most variables, with the exception of

[a] VICTORA, C. G. *Child health in southern Brazil. The relationships between mortality, malnutrition, health care and agricultural development.* Ph.D. thesis, University of London, 1983. pp. 216–221.

father's education (5.6%) and literacy (2.5%). As a consequence, the number of children for which data are shown in Tables 1 to 6 ranges from 757 to 797.

RESULTS

The nutritional status of the children in terms of the cut-offs at −2 and −1 standard deviations below the NCHS median values is shown in Table 1. Stunting was much more frequent (12.3%) than underweight (3.8%) or wasting (0.5%). The weight for length of most of the sample children was higher than that of the reference population.

As shown in Fig. 1, a marked variation in the level of malnutrition as a function of family income was observed, with the prevalences of stunting, underweight, and wasting being approximately 7, 4, and 2 times higher, respectively, among children from the poorest than among those from the wealthiest homes. A test for linear trend using as weighting factor the logarithm of the mean income in each quintile was highly significant for stunting ($P < 10^{-6}$) and underweight ($P < 0.0005$). For wasting, the best fit was provided by a test for linear trend without logarithmic transformation ($P = 0.02$). There were no significant departures from linearity.

Table 2 shows the prevalences of malnutrition according to the employment status of the head of the family. There were too few children whose parents were unemployed or retired to warrant further analysis, but, in general, such children appeared to belong to high-risk groups. Overall differences were only significant for weight for age, but this is probably due to the extreme values of this variable observed for children of unemployed or retired parents. If we disregard these two small groups, there is good correlation between the unadjusted data and the employment status of the head of the family: a higher prevalence of malnutrition was observed among children of employees than of those of the self-employed, which in turn was higher than those of the children of employers. A test for linear trend, however, was only significant for length for age but was not significant after adjustment for family income (not shown in Table 2). Also, no clear trend was found between malnutrition and sector of activity of the head of the family (Table 2). Differences were only significant for length for age, with the prevalence of malnutrition among children of those employed in commerce, service industries, and transport being low, while children of forestry workers fared relatively badly.

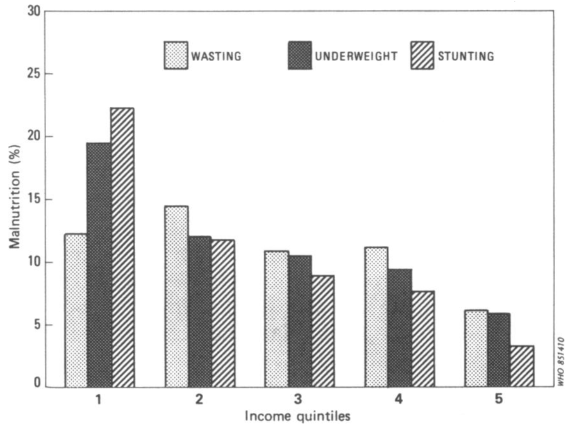

Fig. 1. Proportion of children in the study sample below the 10th percentile for malnutrition (wasting, underweight, stunting) according to per capita family income (expressed in quintiles — see text), 1982 (number of children = 802).

Table 1. Nutritional status of the sample children, 1982

	Proportion of children (%)		
Nutritional status[a]	Length for age	Weight for age	Weight for length
≤ −2 sd	12.3	3.8	0.5
−1.99 to −1 sd	23.6	16.9	7.9
> −1 sd	64.1	79.4	91.6
Number of children	797	795	794

[a] The values refer to the number of standard deviations (sd) below the median of the National Center for Health Statistics (NCHS) values.

The data in Table 3 reveal a marked correlation between the prevalence of malnutrition in children and the number of years of schooling of their parents. Stunting and underweight were nearly twice as common among children whose parents had had no education than among those whose parents had had 1–3 years of schooling. It is interesting to note that the schooling of the father, rather than of the mother, correlated more strongly with the nutritional status of the children. These effects tended to be more marked with length for age and weight for age than with weight for length, and were less when income was taken into consideration. This was particularly true for maternal education. Income and parental education are, of course, strongly correlated, and the effect of income was therefore also investigated after adjusting for schooling of the parents (results not shown in Table 3). Income remained more significant

Table 2. Proportion of children below the 10th percentile of the study sample according to the employment characteristics of the head of the family, 1982

Characteristic	Proportion of children below 10th percentile (%)			No. of children
	Length for age	Weight for age	Weight for length	
Employment status				
Unemployed or casual	16.9 (12.5)[a]	33.7 (29.0)	17.5 (16.7)	16
Retired	17.6 (12.1)	0.1 (0.1)	9.2 (8.3)	20
Employee	11.4 (11.4)	10.6 (10.6)	10.3 (10.3)	349
Self-employed	9.0 (10.1)	9.9 (10.8)	9.2 (9.7)	333
Employer	3.4 (6.7)	5.2 (8.3)	6.4 (8.4)	75
P level	>0.1 (>0.1)	<0.01 (0.01)	>0.1 (>0.1)	
Sector of activity				
Agriculture	9.5 (9.5)	9.9 (9.9)	8.3 (8.3)	324
Forestry	20.6 (16.9)	20.2 (17.6)	7.9 (6.6)	33
Industry	14.1 (12.9)	10.7 (10.1)	11.7 (10.7)	152
Commerce	5.0 (7.5)	6.2 (8.4)	5.3 (5.8)	81
Service industry	2.2 (2.5)	7.6 (9.0)	10.1 (11.0)	104
Transport	6.8 (7.1)	6.9 (7.3)	13.0 (13.2)	50
Government service	11.5 (12.6)	4.1 (4.0)	12.7 (13.4)	47
P level	<0.005 (0.05–0.1)	>0.1 (>0.1)	>0.1 (>0.1)	

[a] The data indicate the proportion of children when district of residence is included in the analysis; the data in parentheses indicate the proportion of children when both district of residence and family income are included in the analysis.

Table 3. Proportion of children below the 10th percentile of the study sample according to education and literacy of parents, 1982

Characteristic	Proportion of children below 10th percentile (%)			No. of children
	Length for age	Weight for age	Weight for length	
Father's schooling				
0 years	26.0 (26.0)[a]	26.0 (26.0)	11.7 (11.7)	77
1–3 years	14.4 (16.2)	13.2 (13.3)	16.1 (16.3)	142
4–5 years	7.8 (10.8)	9.6 (11.0)	11.4 (11.3)	329
6–11 years	6.1 (11.2)	4.6 (5.5)	11.9 (12.6)	126
⩾12 years	4.1 (12.3)	2.9 (4.0)	1.6 (1.8)	83
P level[b]	$<10^{-6}$ (0.005)	$<10^{-6}$ (0.0001)	0.02 (<0.1)	
Mother's schooling				
0 years	22.1 (22.1)	24.7 (24.7)	16.9 (16.9)	77
1–3 years	14.5 (16.0)	13.1 (13.2)	15.5 (14.6)	151
4–5 years	9.4 (13.4)	10.7 (12.5)	13.3 (12.4)	325
6–11 years	9.8 (15.2)	7.6 (8.9)	13.0 (13.1)	144
⩾12 years	3.8 (10.1)	5.2 (7.3)	6.2 (7.3)	91
P level[b]	0.0001 (>0.1)	0.00005 (<0.005)	<0.05 (>0.1)	
Father's literacy				
Literate	7.4 (7.4)	7.1 (7.1)	8.8 (8.8)	708
Illiterate	23.8 (15.8)	25.4 (20.7)	11.8 (11.1)	74
P level	<0.005 (<0.005)	$<10^{-6}$ (<0.00005)	>0.1 (>0.1)	
Mother's literacy				
Literate	7.8 (7.8)	7.1 (7.1)	8.3 (8.3)	718
Illiterate	18.7 (12.7)	22.0 (18.1)	14.8 (15.7)	76
P level	<0.005 0.05	$<10^{-5}$ (<0.0005)	0.05 (0.05)	

[a] See footnote *a* of Table 2.

[b] Obtained in a test for linear trend.

than maternal education for all three indicators, but it was less significant than father's schooling for weight for age and weight for length, although not for length for age. Relative risks of malnutrition of up to 3.5 were also observed when the data were analysed in terms of the literacy of the parents. The relative risks were again less marked for weight for length and, with the exception of this indicator, were higher when correlated with the literacy of the father than with that of the mother. These differences were still evident, although reduced in magnitude, when family income was also included in the analysis.

Table 4 shows that the prevalences of stunting and underweight tended to increase with the number of siblings at home. The situation concerning wasting was less clear, but a similar trend was also indicated. These differences were, however, reduced when family income was taken into consideration.

Brazilian-Portuguese children exhibited the poorest nutritional status, followed by Brazilian-Africans, with mixed Brazilian-Italian and Italian children faring a little better (Table 4). Again, these differences were no longer significant when family income was taken into consideration.

Other socioeconomic variables were also investigated. Children who lived in a separate household to that of the mother or father had a 2 to 3 times higher risk of having poor nutritional status than children who lived with their parents, but there were not enough children in this category to warrant detailed analysis. On the other hand, there was no association between nutritional status and type of family (nuclear or extended) or migration status of the mother or father.

The relationships between the prevalences of malnutrition and a number of environmental and household variables are shown in Tables 5 and 6, respectively. The study of the associations between nutritional status and variables connected with domestic water and sanitation may be confounded by the place of residence, since few rural households have treated water from a public supply. The data in Table 5 consist of information pooled from urban and rural children.

Table 5 shows that stunting, but not underweight or wasting, was commoner in households without piped water in both urban and rural areas. Differences between children were less, but still significant, when family income was taken into consideration. There was no significant association between the source of domestic water and nutritional status of the children; however, wasting was less common among children of rural families drawing water from springs or rivers than among those using a well or a public water supply (there were only 20 children in this last subgroup, all from peri-urban areas). An association was found, however, between the type of sewage disposal and nutritional status. In both urban and rural areas the prevalences of stunting and underweight were relatively low in households with flush toilets, intermediate in those with pit latrines, and highest in those without a toilet (Table 5). These differences were not significant for wasting. Again, differences became less marked when family income was considered, and

Table 4. Proportion of children below the 10th percentile of the study sample according to the number of siblings and ethnic origin of the family, 1982

Characteristic	Proportion of children below 10th percentile (%)			No. of children
	Length for age	Weight for age	Weight for length	
Number of siblings				
0	7.5 (7.5)[a]	6.3 (6.3)	6.3 (6.3)	224
1	7.2 (6.6)	8.7 (8.4)	9.0 (9.0)	244
2	6.7 (5.5)	9.5 (8.9)	12.2 (11.6)	129
3	9.9 (7.2)	6.6 (5.5)	8.1 (7.3)	72
4–5	17.5 (10.2)	21.0 (16.3)	17.8 (16.5)	80
≥6	18.5 (10.6)	17.7 (12.8)	10.6 (10.3)	46
P level[b]	0.001 (0.05–0.1)	0.001 (<0.05)	<0.05 (0.05–0.1)	
Ethnic origin				
Brazilian–Portuguese	16.3 (16.3)	15.4 (15.4)	13.4 (13.4)	306
Brazilian–Italian	5.2 (7.3)	8.0 (9.8)	11.8 (12.5)	153
Italian	7.8 (12.9)	8.5 (12.1)	7.6 (8.5)	314
Brazilian–African	8.8 (7.6)	13.6 (12.2)	14.4 (12.8)	22
P level	<0.005 (0.05–0.1)	0.01 (>0.1)	0.05–0.1 (>0.1)	

[a] See footnote *a* of Table 2.

[b] Obtained in a test for linear trend.

Table 5. Proportion of children below the 10th percentile of the study sample according to water and sanitation characteristics, 1982

Characteristic	Proportion of children below 10th percentile (%)			No. of children
	Length for age	Weight for age	Weight for length	
Piped water				
Inside the house	6.3 (6.3)[a]	8.5 (8.5)	9.0 (9.0)	553
In the compound	8.2 (6.6)	6.0 (4.8)	14.6 (10.9)	53
None	16.8 (11.7)	11.6 (8.4)	8.3 (6.7)	189
P level	<0.0001 (<0.05)	>0.1 (>0.1)	>0.1 (>0.1)	
Source of water				
Treated	8.0 (8.0)	7.5 (7.5)	11.0 (11.0)	348
Well	7.5 (6.2)	11.5 (9.4)	11.7 (10.1)	151
Spring or river	11.6 (8.8)	11.2 (9.6)	6.1 (5.5)	295
P level	>0.1 (>0.1)	>0.1 (>0.1)	0.05 (<0.05)	
Type of latrine				
Flush toilet	4.8 (4.8)	4.1 (4.1)	6.9 (6.9)	390
Pit latrine	11.2 (7.6)	11.8 (10.3)	11.1 (8.9)	324
None	16.2 (10.2)	16.0 (13.5)	9.7 (8.3)	81
P level	0.0001 (0.05–0.1)	0.00001 (0.001)	>0.1 (>0.1)	

[a] See footnote *a* of Table 2.

Table 6. Proportion of children below the 10th percentile of the study sample according to housing characteristics, 1982

Characteristic	Proportion of children below 10th percentile (%)			No. of children
	Length for age	Weight for age	Weight for length	
Building materials				
Bricks or cement	1.6 (1.6)[a]	3.9 (3.9)	7.1 (7.1)	127
Mixed	4.6 (4.1)	3.7 (3.9)	6.8 (5.5)	78
Wood	6.3 (4.8)	7.8 (6.7)	9.1 (6.8)	417
Shack	17.6 (9.8)	16.4 (11.8)	9.9 (7.6)	171
P level	$<10^{-6}$ (0.001)	<0.0005 (<0.05)	>0.1 (>0.1)	
Persons per bedroom				
0–1.9	5.3 (5.3)	5.7 (5.7)	7.1 (7.1)	281
2–2.9	8.1 (6.3)	7.4 (6.3)	8.5 (7.5)	286
3–3.9	14.1 (9.9)	13.1 (10.4)	11.3 (9.7)	126
≥4	15.2 (7.8)	15.4 (10.5)	11.3 (9.3)	101
P level[b]	<0.0005 (<0.05)	<0.0005 (<0.05)	0.05–0.1 (>0.1)	

[a] See footnote *a* of Table 2.

[b] Obtained in a test for linear trend.

remained significant only for underweight. Significant interactions were observed between income and the environmental variables. For both length for age and weight for age, the effects of having piped water were greater in better-off families (at the $P=0.002$ and 0.01 levels, respectively). There was a similar interaction for length for age between type of sewage disposal and income ($P=0.002$) as well as a third-order interaction for weight for length between district of residence, income, and piped water ($P=0.006$).

Table 6 shows that stunting and underweight, but not wasting, correlated strongly with the type of housing, the lowest prevalences being among children living in buildings built wholly or partially with bricks or cement, and the highest among those living in shacks (defined as houses built with irregular pieces of wood or other improvized materials). Once again, when income was taken into consideration the correlation was less pronounced, but did not disappear. The prevalences of stunting and underweight increased 3-fold with the degree of crowding, as expressed by the number of persons per room used for sleeping (Table 6). These differences were reduced when income was taken into consideration. The association with wasting was not significant and disappeared when the data were adjusted for income.

In summary, of the three anthropometric indicators examined, length for age (stunting) and weight for age (underweight) were strongly associated with nearly all of the explanatory variables used, at least before adjustment was made for family income. On the other hand, no strong association was shown by weight for length (wasting).

DISCUSSION

Several points, such as the cross-sectional nature of the study design, the possibility of recall bias for some explanatory variables, the relatively small sample size, and the fact that the survey covered only two districts, should be borne in mind when interpreting the results described here. However, to allow for the separate sampling schemes, the district of residence was taken into consideration in the analysis. Since there was only one significant interaction between the district of residence and the variables examined, nearly all relationships appear to hold for both districts.

The approach used in the multivariate analysis should also be borne in mind when interpreting the results. After adjusting for the district of residence, it was tested whether the effects of risk factors were independent of family income. However, it may be difficult to interpret these adjusted risk factors. For example, if a risk factor remains the same after adjustment, this is evidence for an effect that is statistically independent of the effect of income. Alternatively, a risk factor may be a link in the causal chain between income and malnutrition, and in this case the effect of income would decrease. A third possibility arises if the relative risks are reduced so that differences are no longer statistically significant; it may then be the case that the association between the risk factor and malnutrition may not be causal but because both are associated with income. In other words, income would be a confounding factor that accounted for the association between the risk factor and malnutrition.

In most of the associations studied, the effect of the proposed risk factor was reduced to a certain extent when income was considered. If collinearity between the variables is high, as was the case for most of those studied here, the results must be interpreted with caution. An additional difficulty is that income is only a proxy for social class, and that in the study it was measured imprecisely. The evidence for a causal association between a particular risk factor and nutritional status is therefore strongest when it remains statistically significant after family income is taken into consideration.

In summary, several socioeconomic variables were shown to be strongly associated with the nutritional status of children, and the risk factors family income and father's education had the strongest effect. The variables education of the mother, employment status of the head of the family, number of siblings, and ethnic background also exhibited some degree of association with nutritional status, but this weakened when income was taken into consideration. On the other hand, the sector of activity of the head of the family, type of family, and migration status of the parents were not significantly associated with poor nutrition. Children who did not live with their mother or father had an increased risk of malnutrition, but the small number of children in this category precluded a more detailed analysis.

It is interesting to note that the levels of schooling and literacy of the father, rather than of the mother, were more strongly associated with the nutritional status of children and that these associations were not markedly affected by the confounding effect of income. This suggests that the position of the family in the social structure, rather than any specific beneficial effects of education, is more likely to be causally associated with malnutrition in this population. This finding is supported by a study of child mortality in Rio Grande do Sul, which showed that the family income was a more important risk factor than maternal education (*21*).

Also, after family income had been taken into account, the number of siblings was not nearly as important a risk factor, remaining significant ($P = 0.03$) for underweight only. It should be borne in mind that the per capita income reflects the size of the family, and hence the number of siblings. The income-adjusted effect of the number of siblings therefore represents only the influence of this variable, which is in addition to its diluting effect on the overall income.

The results of the study of environmental risk factors indicated that children were more likely to be stunted in households without piped water, more likely to be wasted in rural families drawing water from wells, and to have poorer length and weight for age as the sewage disposal facilities, type of housing, and overcrowding deteriorated. There were also some second- and third-order interactions between income, district of residence and the variables, but these interactions are difficult to interpret.

The search for associations between environmental factors and malnutrition is based on the hypothesis that a poor environment may increase the risk of acquiring an infectious disease, which in turn may lead to malnutrition. An alternative hypothesis is that both environmental variables and malnutrition are associated with a third, confounding factor. The study analysed these associations both before and after adjusting for the possible confounding effect of family income. The persistence of an association after adjustment favours the first of these hypotheses. We will now examine how the present findings relate to these hypotheses.

Studies of the role played by water in causing diarrhoea indicate that an increased availability of water seems to be associated with a reduced incidence of diarrhoeal disease, irrespective of changes in water quality (*22, 23*). Our findings are consistent with this conclusion, since children with access to treated water did not present with better nutritional status, while the availability of piped water halved the risk of stunting, even after family income was taken into consideration. This is in contrast to the results of a study in Nigeria that showed an increased prevalence of wasting and underweight, but not of stunting, in children living in households with scanty, unprotected water supplies (*11*). Also, a study in Lebanon (*12*) showed an association between an "index of thriving" and availability of piped water in the home. Our findings, i.e., greater prevalence of wasting among rural children using water from wells than among those drawing water from rivers or streams, may be due either to some unidentified aspect of water quality or to confounding factors that have not been taken into account.

The strong association between the type of latrine and stunting was no longer significant when adjusted for income. The association between toilet facilities and underweight, however, remained significant, and children from households without a latrine were three times more likely to have a low weight than those from households with a flush toilet. This apparent effect of sanitation is probably not mediated through contamination of water supplies since there was no association between source of water and low weight for age. In the above-mentioned Lebanese study, children who failed to thrive were also more likely than control children to come from a home without a toilet (*12*).

Both the type of materials used to construct the house and the number of persons per room used for sleeping were strongly associated with stunting and underweight, but not with wasting. Children living in houses built of bricks or cement were better nourished than any other category. After adjustment for income, these children were six times less likely to be stunted and three times less likely to be underweight than those living in shacks. The differences related to crowding were not nearly as strong, being less than twofold. Similar associations between nutritional status and characteristics of the house and crowding were also observed in Jamaica (*13*) and Lebanon (*12*).

One possible mechanism whereby housing and crowding characteristics might affect nutritional status is via the spread of airborne infections. A longitudinal study in the United Kingdom revealed that children who slept alone were less likely to contract measles and mumps, but not whooping cough or chicken pox, than those sharing a bedroom (*24*).

The fact that variables relating to housing conditions were more strongly associated with nutritional status than with variables relating to water and sanitation is consistent with our earlier finding that respiratory diseases, rather than diarrhoea, are the leading infectious causes of infant and childhood deaths in Rio Grande do Sul (*14*).

Our study of child mortality in 1970 and 1980 in Rio Grande do Sul (*21*) also showed an increased risk among families living in poorly built houses with no access to piped water, even after family income and employment status had been taken into consideration. However, there was no advantage in having a supply of treated water.

In summary, the present study revealed that four variables related to environmental characteristics, namely, availability of water, type of sewage disposal, type of building, and degree of crowding, were associated with one or more of the nutritional indicators. Similar findings have previously been reported from other developing countries, but our results also demonstrate that many of these associations remain significant even after the possible confounding effect of family income has been taken into consideration. This finding supports the hypothesis of a causal link between the four above-mentioned environmental factors and malnutrition.

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RÉSUMÉ

FACTEURS DE RISQUE DE MALNUTRITION CHEZ DES ENFANTS BRÉSILIENS: LE RÔLE DES VARIABLES SOCIALES ET ENVIRONNEMENTALES

Les effets de plusieurs indicateurs socio-économiques et environnementaux sur l'état nutritionnel (chétivité, insuffisance pondérale et émaciation) ont été étudiés sur un échantillon de 802 enfants âgés de 12 à 35,9 mois. Les enfants ont été examinés à domicile lors d'une enquête effectuée dans des zones urbaines et rurales de l'état de Rio Grande do Sul, région agricole relativement riche du sud du Brésil. Pour chaque enfant, on a calculé les différences par rapport aux normes du National Center for Health Statistics (exprimées en nombres d'écarts type) et on a considéré comme "mal nourris" les enfants qui composaient la tranche de 10% la plus faible pour chaque indicateur. On a d'abord calculé la prévalence de la malnutrition pour chaque sous-groupe socio-économique ou environnemental. Ces prévalences ont ensuite été recalculées après avoir tenu compte du revenu familial en utilisant un modèle linéaire, semblable à une régression logistique, approprié à l'étude de données courantes. Le revenu familial et le niveau d'études du père étaient les 2 facteurs de risque socio-économiques les plus étroitement associés à l'état nutritionnel. Le niveau d'études de la mère, la situation professionnelle du chef de famille, le nombre de frères et sœurs et l'origine ethnique de la famille étaient également plus ou moins liés à l'état nutritionnel mais les effets de ces variables tendaient à disparaître si l'on tenait compte du revenu familial. Par contre, le secteur d'activité du chef du ménage, le type de famille et l'origine géographique des parents n'étaient pas associés de façon significative à une mauvaise nutrition. Les enfants qui ne vivaient pas avec leur mère ou leur père pouvaient également être associés à la malnutrition mais cette catégorie regroupait trop peu d'enfants pour permettre une analyse détaillée.

L'analyse des facteurs de risque environnementaux a montré que les enfants qui vivaient dans des maisons ayant l'eau courante couraient moins de risque de chétivité que les autres. On notait également plus d'émaciation chez les enfants de familles rurales tirant l'eau de puits que chez ceux de familles utilisant l'eau de rivières ou de ruisseaux. La taille pour l'âge et le poids pour l'âge étaient tous deux plus faibles chez les enfants de familles vivant dans des habitations dont le système d'évacuation des eaux usées était inadéquat et dans des maisons mal construites ou surpeuplées. A l'exception de l'association entre le système d'évacuation des eaux usées et la chétivité, toutes les autres associations entre l'état nutritionnel et des facteurs environnementaux sont restées statistiquement significatives, même après avoir effectué un ajustement pour tenir compte des effets du revenu familial, qui pourraient masquer la relation entre les variables environnementales et nutritionnelles. Ces résultats jettent des doutes sur l'hypothèse fréquemment avancée selon laquelle l'amélioration de l'éducation maternelle se traduirait automatiquement par une meilleure santé de l'enfant dans les pays en développement. Ils suggèrent aussi que les facteurs environnementaux peuvent affecter l'état nutritionnel des enfants, peut-être en augmentant l'exposition aux infections.

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