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Childhood Mortality in Relation to Nutritional Status and Water Supply—a Prospective Study from Rural Malawi

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ABSTRACT. Lindskog, U., Lindskog, P., Carstensen, J., Larsson, Y. and Gebre-Medhin, M. (Departments of Paediatrics and Water in Environment and Society, Linköping University, Linköping, Department of Cancer Epidemiology, Karolinska Institute, Stockholm and Department of Paediatrics, Uppsala University, Uppsala, Sweden.) Childhood mortality in relation to nutritional status and water supply—a prospective study from rural Malawi. Acta Paediatr Scand 77: 260, 1988.

In connection with the introduction of an improved method of water supply in rural Malawi, the nutritional status, morbidity, and mortality among 1 178 children under five were studied during three rainy and three dry seasons. Data were collected at fortnightly home interviews. Nutritional assessment was made twice a year. One hundred and thirty-seven of the children died during the study period, and the probability of dying before the age of five was estimated to 270 per 1 000 children. The mortality risk was related to weight for height ($p<0.001$) and height for age ($p<0.01$) as well as to upper arm circumference ($p<0.001$) and triceps skinfold ($p<0.05$). Mortality among children living in households using the new, piped-water supply tended to be lower than mortality for those using traditional water sources, although the difference was not statistically significant (relative risk 0.4, 95% confidence interval 0.1–1.3). *Key words: childhood mortality, water supply, nutritional predictor, anthropometry, developing country.*

In most developing countries, mortality is high for children living under poor socio-economic conditions. Common childhood diseases, such as diarrhoea, respiratory tract infections and measles, are associated with high mortality. In at least 50% of cases of death in children under five years of age, malnutrition is believed to be an important contributing cause (1). Even moderate malnutrition is assumed to impair immunocompetence (2), leading to more severe and prolonged infectious diseases.

Different types of projects aimed at reducing childhood mortality are being implemented in Third World countries (3). Interventions with improved methods of water supply are regarded as important measures (4, 5). The relation between types of water sources and mortality is complex, however, and highly dependent on the general level of development of the particular society. The effects of different types of water supplies on childhood mortality have been studied previously (6, 7). There seems to be only one study, however, in which the impact on childhood mortality of an intervention programme with improved water supply has been evaluated (8).

This prospective study was part of a more comprehensive evaluation of the effects of an improved method of water supply on the morbidity and nutritional status of children under five years of age (9). In a previous report, we found that improved household water supply did not significantly influence nutritional status under the conditions studied (10). The investigation has now been extended to include the effect of improved household water supply on childhood mortality and to assess the usefulness of nutritional status as a predictor of death.

beginning of each two-month period. Using the log-linear regression method, the statistical comparison was adjusted for both age and time period.

The age-specific mortality was studied by dividing age-at-risk into six groups. The cumulative probability of survival was calculated as the product of the (conditional) probabilities of survival within each age interval, p, where $p=\exp.(-\text{ death rate} \times \text{length of age interval})$ for each age interval. Due to social mobility the child-months at risk are over-estimated, but assuming that there was little correlation between mobility and risk factors, this does not substantially bias the relative risk estimates. However, the cumulative probability of dying is probably somewhat under-estimated.

RESULTS

Mortality. One hundred and thirty-seven children under five years of age died during the period of observation; 61 of these children died during the first year of life (Table 1). The estimated probability of dying before 12 months of age was 130 per 1 000 children, and the probability before 5 years of age was 270 per 1 000. Boys ran a higher risk of dying than girls (relative risk of death 1.54, 95% confidence interval 1.09–2.17). According to observations by the mothers, 31% of the deaths were associated with diarrhoea, 15% with fever, 12% with measles and 6% with respiratory tract infections. For 36% of all deaths no specific cause could be described. The risk of dying in diarrhoea before the age of five was estimated to 9% (Fig. 1).

Mortality varied with the seasons and from year to year (Fig. 2). The lowest mortality occurred during and just after the dry seasons (June–December) and the highest rate during and just after the rainy seasons (February–May). During the entire study period deaths due to measles always occurred during February–August with a peak in May. Morbidity also showed a seasonal pattern; both total morbidity and diarrhoeal diseases displayed peaks at the beginning of the rainy season (December–January) and low levels during the dry season (May–October).

Nutritional status varied according to season and especially according to the age of the child. In general, the nutritional status was poor during the rainy seasons and better during the dry ones. During the first two years of life the children were particularly liable to nutritional impairment (Fig. 3).

Mortality risk in relation to nutritional status. During the entire study period, mortality was inversely related to nutritional status, expressed as weight for height SD scores. The results remained the same after age-standardization. From a nutritional point of view, there was one very poor rainy season, March 1984 (Fig. 2). This period coincided with a mortality peak, in

Table 1. *Age-specific mortality and cumulative probability of survival from birth to five years of age in Chingale, Malawi, 1983–85*

Age interval (months)	Child-months of follow-up	No. of deaths	No. of deaths per child-month (death rate)	Cumulative probability of survival at the end of the age interval
0– 5	2 447	20	0.008	0.95
6–11	2 675	41	0.015	0.87
12–17	2 603	19	0.007	0.83
18–23	2 727	13	0.005	0.81
24–35	5 447	24	0.004	0.77
36–59	9 623	20	0.002	0.73
0–59	25 522	137	0.005	

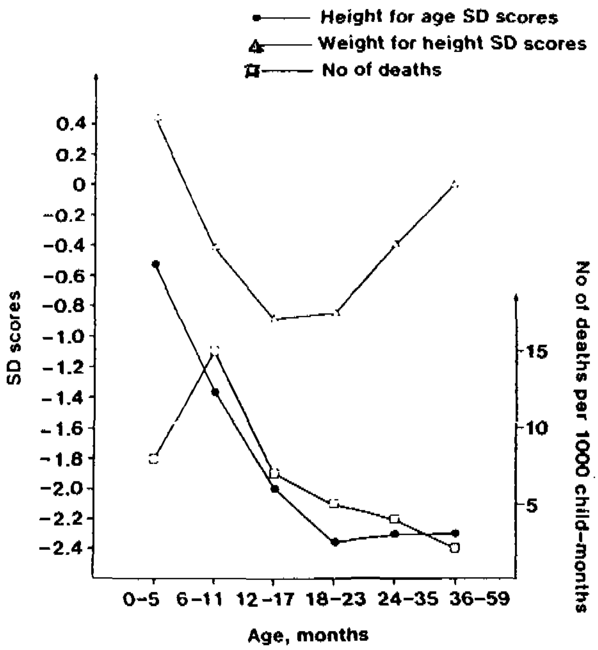

Fig. 3. Weight for height SD scores, height for age SD scores (mean values from three dry and three rainy seasons) and number of deaths per 1 000 child-months in relation to age.

Mortality risk in relation to water supply. The mean amount of water drawn, regardless of water source, was 12.8 litres per person and day before the intervention and 15.5 litres at the end of the first year after the intervention. This increase in water use was statistically significant ($p<0.001$). However, there was no relationship between quantities of water used and

Table 2. *The relative risk of death for children under five in relation to height for age, weight for height and weight for age*

	Child-months of follow-up	No. of deaths	Relative risk[a]	Test for trend
Height/age SD-score				
Above −1	4 507	22	1.00[b]	
−2 to −1	5 127	22	1.46	$p<0.01$
−3 to −2	5 108	19	1.71	
−4 to −3	2 671	15	2.79	
Below −4	1 154	6	3.30	
Weight/height SD-score				
Above 0	7 987	21	1.00[b]	
−1 to 0	6 407	29	1.98	$p<0.001$
−2 to −1	3 384	23	2.75	
Below −2	789	11	5.50	
Weight/age SD-score				
Above −1	6 782	23	1.00[b]	
−2 to −1	6 159	24	1.76	$p<0.001$
−3 to −2	4 147	19	2.12	
Below −3	1 147	18	4.99	

[a] Adjusted for age and period.
[b] Reference group.

height, and the two latter showed the strongest correlation to mortality. Even modestly decreased weight for height (W/H between 0 and −1 SD) almost doubled the risk of dying, and for children below −2 SD the risk increase was five-fold. Upper arm circumference, which is a simple method for field conditions, showed high predictive value; this is of great practical importance in evaluating interventions aimed at improving nutritional status. Even without correction for age, arm circumference can effectively discern relative mortality risks (27).

It has been pointed out (21) that anthropometric indicators are more powerful in discriminating mortality risks in populations in which food intake depends on socio-economic conditions, than in populations in which this is not the case. However, in our population food production and food intake were based on subsistance farming, and thus, relatively independent of factors such as income, occupation, and education. In spite of this, anthropometric parameters were highly predictive of subsequent mortality. Morbidity and inadequate food intake in combination seem to be the main causes of malnutrition.

Available data indicate that malnutrition leads to altered immune response (2, 28) with prolonged and more severe attacks of infections, e.g. diarrhoeal diseases (29, 30). In the present study, there was higher mortality in seasons in which children had a poorer nutritional status, in spite of apparently similar prevalence of morbidity. However, the severity and etiology of diseases were not determined. The highly significant correlation between the level of nutritional status and mortality indicates a causal connection between these two. One possible explanation of this relationship might be that morbidity is a confounding variable, causing both malnutrition and mortality. However, this does not compromise the predictive value of the nutritional indicators.

In households using the piped water, both total mortality and diarrhoea-specific mortality of children were somewhat lower. It cannot, however, be excluded that these differences were due to chance. Decreased mortality due to the use of cleaner water would most likely be mediated through a decreased incidence of diarrhoeal diseases, since water supply has little direct effect on the other major causes of death (i.e. febrile illnesses, measles, malaria, respiratory infections etc.). From a nutritional point of view, the children in households that were to receive the improved water were similar to those in households that were not to receive the water. An evaluation during the first after-intervention year showed no significant nutritional impact of the improved water supply (10). At the tap, piped water contained a smaller number of faecal coliforms than water from traditional sources ($p<0.001$), but considerable contamination occurred later during storage (31). The lack of statistically significant effect of piped water might thus partly be explained by unhygienic handling and storage of the water but also by the low number of piped-water users during the rainy season when the mortality peak occurred.

In a study from Bangladesh (8), it was found that poor environmental sanitation and large household size were related to increased mortality after the neonatal period, while the effects of type of water source were not statistically significant. In the present study area, 70% of the households had simple pit-latrines. However, young children did not use them, and there was considerable faecal contamination of the close surroundings of the homes. With regard to this, there were comparatively small differences between households; any essential variation in hygienic habits and personal cleanliness would probably have been difficult to quantify and measure. During the after-intervention year, the quantities of water used increased. There was no significant relationship between amounts of water used and mortality risk, probably because the quantities were still small at the end of the study. It is likely that in environments with a high exposure to intestinal pathogens, improved sanitation may be more important than improved water supply (5, 6).

In many societies lack of breastfeeding is a key factor determining mortality (6, 32). The rural Malawian society in this study, characterized by prolonged lactation, is homogeneous in this respect. Also, the age when weaning started varied little (usually during the second month of life). It has previously been shown (6) that breastfeeding considerably reduces the importance of water supply and sanitation as determinants of infant mortality. This may partially explain the lack of significant association between type of water supply and mortality in this study.

In conclusion, a tendency towards reduced mortality for children using an improved water supply was found. Furthermore, it was shown that anthropometric data can be used to predict the risk of childhood mortality. Access to clean water in itself may reduce mortality, but it is also a necessary pre-requisite for other intervention programmes to be efficient. The fight against malnutrition and the associated increased mortality should include measures against infectious diseases and the promotion of nutrition during and after infections, as well as improved sanitation and hygiene. Further studies focusing on the role of a clean water supply in such programmes are needed.

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