PREVALENCE AND SEVERITY OF MALNUTRITION IN PRE-SCHOOL CHILDREN IN A RURAL AREA OF WESTERN KENYA

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Abstract. We determined the nutritional status of children less than five years of age in an area in rural western Kenya with intense malaria transmission, a high prevalence of severe anemia and human immunodeficiency virus, and high infant and under-five mortality (176/1,000 and 259/1,000). No information is available on the prevalence of malnutrition in this area. Three cross-sectional surveys were conducted between 1996 and 1998 to monitor the effect of insecticide-treated bed nets on child morbidity. Anthropometric indices are presented for 2,103 children collected prior to and during intervention (controls only). The prevalence of stunting (Z-scores for height-for-age [HAZ] < -2), wasting (Z-scores for weight-for-height [WHZ] < -2) and being underweight (Z-scores for weight-for-age [WAZ] < -2) was 30%, 4%, and 20%, respectively. This was severe (Z-score < -3) in 12% (stunting), 1% (wasting), and 5% (underweight) of the children. Few children less than three months of age were malnourished (<2%), but height-for-age and weight-for-age deficits increased rapidly in children 3–18 months of age, and were greatest in children 18–23 months old (44% stunted and 34% underweight). While the mean HAZ and WAZ stabilized from 24 months of age onwards, they still remained substantially below the reference median with no evidence of catch-up growth. Malnutrition is likely to interact with infectious diseases, placing children 3–24 months of age at high risk of premature death in this area.

INTRODUCTION

The fourth report on global nutrition showed that the scope of malnutrition is still unacceptably high and progress to reduce it in most regions of the world is slow.1 It was estimated that in the year 2000, 182 million pre-school children, or one-third of children less than five years old in developing countries were stunted, reflecting long-term cumulative inadequacies of health and/or nutrition.2 Approximately 27% were estimated to be underweight.3 While the overall trend in nutritional status in developing countries over the last 20 years is one of improvement, and is expected to continue, the United Nations region of eastern Africa (which includes Kenya, but also higher-risk countries such Djibouti and Ethiopia) is the only region where the trend has been in the opposite direction. The prevalence of stunting and being underweight among pre-school children in this region are now estimated at 48% and 36% and are expected to increase further over the next decade.1

In Kenya, the prevalence of stunted and underweight children remained stable throughout the 1990s, as did the gross national product per capita, while the less than five mortality rate increased slightly from 105/1,000 to 112/1,000.4 The Kenyan National Council for Population and Development’s estimates of the prevalence of malnutrition in 1997–1998 in children less than five years of age showed a large variation by province, reflecting the considerable variability in environmental and socioeconomic risk factors. These estimates were approximately 33.0% (stunting), 22.1% (underweight), and 6.1% (wasting) for Nyanza Province in western Kenya.5 It is unknown whether these statistics apply to our study area in Asembo, where malaria studies have been undertaken over the past 20 years. This poor rural area located in Nyanza province in western Kenya has intense malaria transmission and a high prevalence of human immunodeficiency virus (HIV). Both malaria and HIV are perceived as the main contributors to the very high infant and less than five mortality (176/1,000 and 259/1,000) in this area, which is considerably higher than in other parts of Kenya.5 We have previously shown that the main burden of malaria in this area is in a relatively narrow range between 3 and 16 months of age, after which children who survived have acquired sufficient clinical immunity to be protected from severe malaria.6 This period of highest risk overlaps with the main risk period for iron deficiency anemia (4–6 to 24 months).7 Furthermore, approximately 35–45% of HIV-1-infected children are estimated to die within the first 24 months of life.8,9 While public perception assumes that children in this area are prone to malnutrition, no data have been available to support this, or to make comparisons with other populations. As part of a large, randomized, controlled intervention study of insecticide (permethrin)-treated bed nets (ITNs), we monitored all-cause morbidity and standard parameters of malnutrition in a series of cross-sectional surveys involving a random selection of pre-school children.10 The aim of this report is to describe the nutritional status of these children and to determine the main age groups at risk of malnutrition. Only data collected prior to the introduction of ITNs, and subsequent data from control villages are used for this analysis.

MATERIALS AND METHODS

Details of the ITN trial site and methods have been described in detail elsewhere.11,12 Briefly, the study site is in Asembo, located on the shores of Lake Victoria, in Bondo district of western Kenya. The population is ethnically homogeneous; more than 95% are members of the Luo tribe. The main occupations are subsistence farming (mainly maize, sor-
ghum, cassava, millet, and a few vegetables) and some animal husbandry (a few heads of cattle and goats or chicken). Other activities include fishing in Lake Victoria and management of retail and hotel outlets. Weaning occurs in 70% of the children by 18 months (Alaii JA, unpublished data). Malaria transmission is intense and occurs throughout the year. The prevalence of HIV among pregnant women in this community was 18% in 1992–1996 (Kenya Medical Research Institute/Centers for Disease Control and Prevention, unpublished data). Approximately 5–9% of infants overall would be expected to be infected with HIV, assuming 25–48% mother-to-child transmission in the context of extended breastfeeding.15

Between October 1996 and December 1998, three cross-sectional surveys were conducted in 60 villages to determine the impact of ITNs on all-cause morbidity in pre-school children.10 The baseline survey (survey 0) was conducted just prior to the distribution of the ITNs in December 1996 and used two-stage random cluster sampling (27 village-clusters, then sampling children from these). The other two surveys (survey 1 and survey 2) were conducted in February–March and November–December 1998; 14 and 22 months after half of the villages (selected at random) had received ITNs. Simple random sampling was used for these surveys with households as the sampling unit. A different sample of children was selected for survey 1 than for survey 2. Full details of the design and methods used in these surveys and the impact of ITNs on nutritional parameters have been published elsewhere.10

Measurements were performed according to standard procedures of the World Health Organization.16 Children less than six months old were undressed and weighed to the nearest 10 grams using a 10 kg ± 10 g hanging weighing scale (Salter, Smethwick, United Kingdom). The weight of the older children, wearing light clothes only, was measured to the nearest 100 grams using a 25 kg ± 100 g hanging weighing scale (CMS Weighing Equipment, London, United Kingdom). Scales were calibrated daily. Recumbent length (children under six months old) was measured to the nearest 0.1 cm using wooden scales (CMS Weighing Equipment, London, United Kingdom). Scales were calibrated daily. Recumbent length (children under six months old) was measured to the nearest 0.1 cm using wooden measuring boards with a sliding foot or head piece.17 The Z-scores for height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) were calculated using reference data from the U.S.-based National Centers for Health Statistics (NCHS) and the World Health Organization18 in EPI-Info version 6 (Centers for Disease Control and Prevention, Atlanta, GA). Children were classified as stunted, underweight, or wasted if their HAZ, WAZ, or WHZ was < -2, respectively. Severely malnourished children were referred to the local hospital and a nutritional feeding center, which was located in the center of the study area.

The total number of children enrolled and the age distribution varied by survey due to oversampling of infants in survey 0 and exclusion of children ≥36 months of age in survey 1.10 The analysis of the prevalence and mean Z-scores was therefore weighted by age, using the known age distribution of the children enrolled in the ITN trial as the reference. The analysis was also weighted by survey such that data from each survey contributed equally to the final data set for children less than 36 months of age (33.3% each). Survey 0 and survey 2 contributed 50% each to the 36–59-month-old age group. Clustering of children at the household level was controlled for, to obtain the 95% confidence intervals of the point estimates of the prevalence of the nutritional parameters (SUDAAN version 8.0, SAS callable version; Research Triangle Institute, Research Triangle Park, NC). Confidence intervals for rare outcomes (<5%) were calculated using Exact methods (StatXact version 4.0.1; Cytel, Cambridge, MA).

The ITN trial was reviewed and approved by the institutional review boards of the Kenya Medical Research Institute (Nairobi, Kenya) and the Centers for Disease Control and Prevention (Atlanta, GA). Written informed consent was obtained from caregivers for each individual participant.

RESULTS

A total of 2,316 children less than five years old were enrolled in the study. This included 1,132 children from 27 (subsequent) ITN and control villages in survey 0 and 1,184 children from 30 control villages in surveys 1 and 2. One-hundred ninety-three children from control villages in survey 0 were also enrolled in surveys 1 or 2, and only the latter contribution was included in the analysis. Eleven children were excluded because they were just over the maximum age limit. Anthropometric data were missing for nine other children. The characteristics of the remaining 2,103 children (with at least one anthropometric observation) are shown in Table 1.

Based on exclusion criteria described by the World Health Organization,2 100 of 2,103 children had biologically implausible values for height and 32 for weight. This resulted in complete values for HAZ, WHZ, and WAZ of 2,003 (95.2%), 2,040 (97.0%), and 2,071 (98.5%) (Table 2). While the SD for the WHZ distribution (1.08) (after exclusion of implausible values) was within the range recommended by the World Health Organization (0.85–1.10), the SDs for the HAZ (1.42) and WAZ (1.27) distributions were outside the recommended

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Characteristics of 2,103 children less than five years old*</th>
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<tbody>
<tr>
<td>Baseline survey (survey 0): Oct–Nov 1996 (%)</td>
<td>935/2,103 (44.5)</td>
</tr>
<tr>
<td>Survey 1: 1st intervention period survey: Feb–Mar 1998 (%)</td>
<td>478/2,103 (22.7)</td>
</tr>
<tr>
<td>Survey 2: 2nd intervention period survey: Nov–Dec 1998 (%)</td>
<td>690/2,103 (32.8)</td>
</tr>
<tr>
<td>Age in months, median (range)</td>
<td>22.4 (0.13–59.9)</td>
</tr>
<tr>
<td>0–5, No. (%)</td>
<td>304/2,103 (14.5)</td>
</tr>
<tr>
<td>6–11, No. (%)</td>
<td>345/2,103 (16.4)</td>
</tr>
<tr>
<td>12–23, No. (%)</td>
<td>458/2,103 (21.8)</td>
</tr>
<tr>
<td>24–35, No. (%)</td>
<td>494/2,103 (23.5)</td>
</tr>
<tr>
<td>36–59, No. (%)</td>
<td>502/2,103 (23.9)</td>
</tr>
<tr>
<td>Sex no. of males (% [95% CI])</td>
<td>1,035/2,103 (49.2 [47.0–51.4])</td>
</tr>
<tr>
<td>Clinical examination</td>
<td></td>
</tr>
<tr>
<td>Axillary temperature ≥37.5°C, No. (% [95% CI])</td>
<td>153/2,042 (7.5 [6.3–8.6])</td>
</tr>
<tr>
<td>Height in cm, mean (95% CI)</td>
<td>479.8 (78.8–79.9)</td>
</tr>
<tr>
<td>Weight in kg, mean (95% CI)</td>
<td>10.4 (10.3–10.6)</td>
</tr>
<tr>
<td>Thin flaky skin texture, No. (% [95% CI])</td>
<td>15/690 (2.2 [1.2–3.6])</td>
</tr>
<tr>
<td>Visible severe wasting, No. (% [95% CI])</td>
<td>14/689 (2.0 [1.1–3.4])</td>
</tr>
<tr>
<td>Light thin hair color, No. (% [95% CI])</td>
<td>58/690 (8.4 [6.2–10.6])</td>
</tr>
<tr>
<td>Bipedal edema, No. (% [95% CI])</td>
<td>10/690 (1.4 [0.1–2.7])</td>
</tr>
</tbody>
</table>

* CI = confidence interval.
† Data collected during the last cross-sectional survey in 1998 only (n = 690).
range (HAZ = 1.10–1.30, WAZ = 1.00–1.20). The SD for the HAZ and WAZ distributions increased gradually with age, whereas there was no trend with age for the WHZ distribution, suggesting inaccurate age assessment of older children.

The weighted mean HAZ and WAZ in children less than three months of age were near or above the NCHS/WHO reference median (Figure 1). A subsequent sharp decrease in mean Z-scores that continued until the age of approximately 18 months was seen after which the decrease slowed down and the mean Z-scores leveled off, running parallel to, but substantially below, the reference line. A similar pattern was seen for weight-for-height, with the exception that the mean Z-score values continued to increase after 24 months and stabilized around the reference median. Analysis of the distribution curves for the HAZ and WAZ illustrated that the Z-score distribution of the entire population was shifted downwards, such that the low mean Z-scores could not be explained by a skewed distribution curve.

The prevalence of stunting was 29.5% overall (Table 2) and started to increase from the age of three months onwards, peaked in the 18–24-month-old age group (44.3%), and remained relatively stable from the age of three years onwards (35.7%) (Figure 2). The overall prevalence of underweight was 20.2% and showed a similar age-related pattern to that observed for stunting (Figures 1 and 2). Severe wasting was rare (WHZ <−3 = 0.6%). Approximately 1% of the children in survey 2 had evidence of either kwashiorkor or marasmikwashiorkor.

**DISCUSSION**

In this sample of Kenyan children less than five years of age from a poor rural area of intense malaria transmission who experience high morbidity and an increasing seroprevalence of HIV, 30% and 20% of the children were stunted and underweight, respectively. In children 6−59 months old, the age group most commonly assessed in nutritional surveys and used for most international comparisons, this prevalence was slightly higher; 35% and 22%, respectively. According to the classification of worldwide prevalence ranges for stunting and underweight used by the World Health Organization, these levels are classified as high. Our prevalence estimates are comparable with recent estimates from areas with less intense malaria transmission in Nyanza province.

The similarity in the age pattern of the HAZ and WAZ, and the low prevalence of wasting, suggest that deficits in weight-for-age, which is influenced by both acute and long-term processes, were more closely related to long-term processes. Children in the first three months of life were relatively unaffected, with both weights and heights similar to that of the NCHS/WHO reference population. Presumably the in utero experience is the main determinant of the nutritional status in this period. However, the Z-scores decreased rapidly from three months onwards and continued to decrease until they reached their nadir at approximately 18–22 months and remained low until the age of 24 months. Mean WAZ and HAZ subsequently increased and stabilized from the age of 24–30 months onwards, albeit substantially below international reference medians, after which little change occurred. This age pattern in mean Z-scores is consistent with other reports from sub-Saharan Africa.

Analysis of the distribution curves for the HAZ and WAZ illustrated a downward shift of the entire distribution curve; i.e. the impact on protein energy nutritional status was a generalized phenomenon and was not restricted to children at risk, but also included children not classified as malnourished (i.e. with Z-scores ≥−2). This suggests that most chil-

### Table 2
Age-standardized prevalence of stunting, wasting, and underweight and mean Z-scores*

<table>
<thead>
<tr>
<th>Age</th>
<th>Height-for-age</th>
<th>Weight-for-height</th>
<th>Weight-for-age</th>
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<tbody>
<tr>
<td></td>
<td>0–5 months</td>
<td>6–59 months</td>
<td>All</td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;-3Z, % (95% CI)</td>
<td>1.5 (0.6, 3.9)</td>
<td>13.2 (11.5, 15.0)</td>
<td>11.8 (10.2, 13.3)</td>
</tr>
<tr>
<td>&lt;-2Z, % (95% CI)</td>
<td>5.1 (2.3, 7.9)</td>
<td>32.9 (30.5, 35.4)</td>
<td>29.5 (27.3, 31.7)</td>
</tr>
<tr>
<td>Z-score, mean (95% CI)</td>
<td>-0.32 (-0.46, -0.19)</td>
<td>-1.40 (-1.48, -1.32)</td>
<td>-1.27 (-1.34, -1.20)</td>
</tr>
</tbody>
</table>

* CI = confidence interval.

![Figure 1](image-url)
dren did not reach their maximum growth potential and that interventions should be directed at all children in the age range at risk, not just those already considered malnourished. It also suggests that mean $Z$-scores, rather than the prevalence of stunting or being underweight, should be the primary end points to assess the efficacy of population based interventions, such as ITNs.

The high prevalence of stunting reflects the compromised overall health in this population, which is consistent with its very high infant and less than five mortality rate. There is a strong association between the severity of weight-for-age deficits and mortality rates, but even mild malnutrition, which is much more common, augments case-fatality rates of disease. This synergism has been found to be strongest in populations with high morbidity and malnutrition. Although determination of the main causal factors for stunting and being underweight is beyond the scope of this report, it is noted that the time frame of the greatest decrease in mean $Z$-scores found in this study (3–18 months of age) coincides with the time of weaning (70% by 18 months of age), as well as that of the peak burden of malaria morbidity and mortality in this population, and overlaps with the highest risk period for iron deficiency. In the current sample, 86% of children 3–24 months of age were anemic (hemoglobin level <11 g/dL), of whom 22% had moderately severe anemia (hemoglobin level <7 g/dL), and 70% had *Plasmodium falciparum* parasitemia. Mother-to-child transmission of HIV, which affects between 5% and 9% of the infants in this area, is increasingly contributing to a poor nutritional status and high mortality in this area. Thus malnutrition and infectious diseases are likely to interact during this time period, resulting in compromised growth and high mortality in children 3–24 months of age.

It is also apparent from the lack of increase in the mean HAZ and WAZ that little or limited catch-up growth occurs later in childhood among the survivors. After weaning, children must derive nutrition from a monotonous diet, depending heavily on the staple of white maize, with little nutritious accompaniments. Thus, under these circumstances, the relative advantage of weight and height gain resulting from short-term interventions (such as ITN use in the first two years of life) would be expected to have long-term benefits relative to a control population if catch-up growth is absent in the latter.

Two of the three surveys were conducted after the introduction of ITNs in the neighboring intervention villages. The ITNs were found to beneficially affect gains in weight and height. Although children living in intervention villages were excluded from these latter two surveys, bed nets were also found to exert a mass or community effect, resulting in marked reductions in mosquito populations, symptomatic malaria, and severe malarial anemia in control households located within 300 meters of bed net villages. Despite a clear effect on malaria-specific parameters, there was no evidence for a community effect on any of the standard nutritional parameters (Hawley WA and others, unpublished data). Thus, although a small community effect cannot be excluded, it is unlikely that this will have resulted in a substantial underestimation of the prevalence of malnutrition in this analysis.

The quality of the anthropometric measurements requires further comment. The SD values for HAZ and WAZ distributions were greater than the recommended range of the World Health Organization and increased with age, whereas the SD of the WHZ distribution was in range. This suggests that the larger than expected variation was likely related to inaccurate age assessment of older children, rather than inaccurate assessment of weight or height. This resulted in a flattening of the overall $Z$-score distribution curves and reduced precision (resulting in larger confidence intervals) of the mean $Z$-score and prevalence estimates of the age based observations in older children. Although we were unable to determine this, we have no reason to believe that this would have resulted in a substantial bias of these point estimates, since the error in age determination in older children is likely...
to have occurred at random, which would not result in a systematic overestimation or underestimation of age in one group only. We therefore believe that the point estimates are valid and representative for this age group in this area.

This study demonstrates a high overall prevalence of stunting and underweight in this poor rural area with intense malaria transmission. Few children, not only those classified as malnourished, reach their maximum growth potential. Children were at greatest risk in their second year of life (12–24 months), as reflected in the continued decrease in mean Z-scores between the ages of 3 and 18 months. This time frame coincidences with the highest risk period for all-cause morbidity; the infection between infectious diseases and malnutrition is likely to augment case fatality rates. Given both the acute and long-term consequences of malnutrition in this vulnerable age group, community-based interventions aimed at reducing child malnutrition in such populations should focus on all children less than two years of age.

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