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Original Article

Protein-Energy Malnutrition in Two Cohorts of Children in a Malaria Endemic Region of Western Kenya

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Abstract

Background: Protein-Energy Malnutrition is a major problem in most developing countries. The earliest age for accurate assessment is still a challenge.
Objectives: To compare the prevalence of malnutrition and determine the impact of bednets on overall morbidity and mortality in preschool children in two groups; aged 0 to 5 months and 6 to 59 months in a high malaria endemic area in Western Kenya.
Study design, settings and duration: Three cross-sectional surveys were conducted in Asembo, Rarieda Division, South-West of Kisumu city, Western Kenya between 1999 and 2005 as part of the bednet project.
Subjects and Methods: Nutritional status of the children aged between 0 to 6 months then 6 to 59 months, in the study area was done using anthropometric measurements. Statistical analysis was carried out using Chi-square tests or Fisher's exact test, relative risk and odds ratio (OR) with 95% confidence intervals.
Results: Out of 2112 children, stunting was present in 29.5%. Children in the first 3 months of life were relatively unaffected by stunting or underweight. The prevalence of stunting showed a rise from the age of 3 months onwards, peaked between 18-24 months (42.1%) and remained relatively stable between 36-59 months (35.7%). The overall prevalence of underweight was 20.2% and age related pattern was similar to that observed for stunting. The weight gain was only apparent in infants aged 0-3 months.
Conclusion: Children in the first 3 months of life were relatively unaffected by stunting or underweight but intervention showed a positive effect on general nutritional status.
Policy message: Protein Energy malnutrition could be assessed with accuracy in children between 6 to 59 months.
Key words: Protein energy malnutrition, children, bed-nets, Western Kenya.

Introduction

Malnutrition can be caused by both under and over nutrition.[1] Protein-energy malnutrition (or protein-calorie malnutrition) also occurs due to inadequate or excess protein intake. Severe protein energy malnutrition (PEM) describes a spectrum of clinical syndromes ranging from kwashiorkor to severe marasmus.[2,3] Kwashiorkor is characterized by the presence of edema and has a high mortality rate.[4]

Worldwide, the prevalence of malnutrition is around 40%. In Africa it is 26% while in Asia it is 76%.[5] In Southern Africa, from 2000 and 2013, the prevalence of overweight increased from 11% to 19% while, in Southeastern Asia it increased from 3% to 7%.[5] In Kenya, the prevalence of underweight children under five years of age has also halved due to better infant feeding practices. [6] The better figures for Africa including Kenya are due to massive feeding interventions in mothers and infants.

Comparing the nutrition data of Kenya demographic and health survey, Kenya Demographic Health Survey (KDHS) 2008-09 with 2014 shows overall improvement in nutritional status of children where stunting has decreased from 35% to 26%. Wasting has also declined from 7% to 4%, and the proportion of underweight children declined from 16% to 11%. The general prevalence of malnutrition in the country are

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stunting 26%, wasting 4% and underweight 11%.[6,7] Prevalence of stunting is 27% (medium) wasting is 5% (low) and underweight is 20% (high) as per classification of United Nations.[5]

More than a third of all children in the developing countries remain constrained in their physical growth and cognitive development due to undernutrition. Two global regions of Eastern and Western Africa are actually showing a significant increase in prevalence unlike South Asia, which is showing a slow drop in undernutrition.[5,8,9] The Caribbean and South America are the only regions that have managed the reduction of undernutrition by half by the year 2000.[9]

Malaria remains a significant health problem in many tropical areas but its main impact is in sub-Saharan Africa, where it causes high deaths and morbidity.[10] There is controversy on the effects of PEM on malaria tropica (effects of *Plasmodium falciparum* in areas having high PEM).[11-14] Recent studies show that PEM is associated with higher malaria morbidity and mortality in humans[15,16] especially those having stunting.[14,17- 20]

This work was done to compare the prevalence of malnutrition in children 0-59 years and determine the impact of bednets on overall morbidity and mortality in preschool children in Western Kenya.

Subjects and Methods

The study was conducted in Asembo, Rarieda Division, South-West of Kisumu town, which is situated north east of Lake Victoria, and very close to the equator, in Western Kenya. This area is representative of many parts of sub-Saharan Africa with intense perennial malaria transmission.[10,11] Previous cross-sectional surveys indicated that the prevalence of malnutrition in this area was 6-7%. This study was conducted parallel to a large study evaluating the impact of permethrin-treated bednets on childhood morbidity and mortality,[18] and provided the baseline information on anthropometric indices. The results of the impact of bednets on nutritional parameters is described in detail elsewhere.[18] The current nutritional study was conducted in 60 adjacent villages in an area of 130 km^2. According to the bi-annual census conducted as part of the bednet project, approximately 5150 children aged < 5 years live in this area.

Between October 1999 and December 2003, three cross-sectional surveys were conducted as part of the bednet project to determine the impact of bednets on all cause morbidity in pre-school children.[18] The first cross-sectional survey represented the baseline survey and was conducted prior to the distribution of the bednets to intervention villages in December and during short rains. (average daily rainfall in mm in the previous 3 months: 2.1mm). The second and third surveys were conducted in the months of February-March and November-December, 2004. All the three cross sectional surveys were used to generate data reported here.

The design of the baseline cross-sectional survey (survey-0) was different from the cross-sectional surveys after the start of the bednet intervention (survey-1 and survey-2). Details of this are reported elsewhere.[18,19,21]

Anthropometric measurements were performed according to standard WHO procedure.[22] Children aged < 6 months were undressed and weighed in plastic weighing pants to the nearest 10 grams using a 10kg ± 10g hanging weighing scale (Salter, UK). Weight of the older children, wearing light clothes was measured to the nearest 100 grams using a 25kg ± 100g hanging weighing scale (CMS, UK). The weighing scales were calibrated daily. Recumbent length of children aged less than two years was measured to the nearest 0.1 cm, using a horizontal measuring board with a sliding foot piece. Standing height was measured in the children from 2 years of age to the nearest 0.1 cm using a wooden length-measuring board with sliding head bar. Height and length were measured when children were barefoot and after removal of headgear.[17] Both height boards were manufactured locally using internationally recommended design and specifications.[22] The Mid-upper Arm Circumference (MUAC) was measured to 0.1 cm using specialized non-stretchable measuring tapes (Zerfuss insertional tapes, Ross ltd, USA). All anthropometric measurements were taken by the same two member team throughout each survey to minimize inter-observer variation. During survey-1 and survey-2 each measurement was taken twice and the mean computed.

This study was conducted in parallel with a large study of the impact of permethrin-treated bednets on childhood morbidity and mortality [18,21] and provided the baseline information to determine the impact of this population-based intervention on anthropometric indices. Anthropometric measurements were recorded (see below), and a finger-prick blood sample (400ul) was taken for the determination of haemoglobin concentrations and the presence of malaria parasites.

As bednets are known to impact growth [23] therefore, all children living in villages using bednets were excluded from this analysis, which aimed to describe the prevalence of malnutrition in this community. Large scale use of bednets is recognized to exert a 'mass effect' or community effect.[12,24]

The malariometric indices studied included clinical and laboratory variables. Malnutrition appeared as an important health problem in the study area based on the prevalence rates,[19] therefore, it became necessary to determine the risk factors predisposing children 6-59 months of age to malnutrition. A cohort of children identified to have the highest prevalence of malnutrition based on age range of 18-23 months [18,19,20] was also assessed for possible risk factors for malnutrition. No previous study had reported risk factors for PEM specifically for this rural area that is endemic to malaria.[18,20]

Data management was carried out as detailed earlier.[18,19,25] Data were cleaned using range and internal consistency checks. Nutritional indices were generated with EPINUT (Epi Info v6, 2002 Atlanta, GA, USA). The analysis was weighted such that data from each survey contributed equally (33.3% each) to the final data set in the < 36-month age groups. Only survey-0 and survey-2 contributed to the 36-59 month age group (50% each). Differences in proportions were analyzed using Chi-square tests or Fisher's exact test when appropriate, as well as the relative risk with 95% confidence intervals. The kappa score was used to assess the level of agreement between the Cambridge and the WHO MUAC-for-age indices, as well as between the MUAC-for-age and the three other nutritional indices. Differences in proportions were analyzed using the odds ratio (OR) with 95% confidence intervals in the 3 cross sectional surveys carried out at different times. As in survey-1 and survey-2 the randomization was by household rather than by individual. Clustering of children at the household level was controlled for by age to obtain the 95% confidence intervals for the point estimates of the prevalence of the nutritional parameters as well as for the relative risks when comparing point estimates.[18,19,25,26] This was done using SUDAAN v8.0, SAS callable version, Research Triangle Institute, USA. Confidence intervals for rare outcomes (< 5%) were calculated using Exact methods (StatXact 4.0.1, Cytel, USA). All other analyses were conducted using SPSS (SPSS for Windows version 10.0.7 and 11.0, SPSS Inc). For all statistical tests, *p*-value < 0.05 was considered significant.

The bednet project was approved by the Institutional Review Boards of the Kenya Medical Research Institute (KEMRI), Nairobi, Kenya and by the Centers for Disease Control and Prevention (CDC), Atlanta, USA as well as Ministry of Education Science and Technology, Kenya. Written informed consent was obtained from caretakers for each individual participant.

Results

Out of a total of 3575 children enrolled, only 2112 children were included in the final analysis (Table).

These are already described in detail in the earlier publication.[17,19,26,27,28] Briefly, Z-score distributions for nutritional status as measured by the HAZ, WAZ as well as the WHZ were determined. Z-score values above the statistically defined cut-off of -2 SDs relative to the reference mean were then taken. The prevalence of any (<-2Z) and severe (<-3Z) stunting, wasting, underweight and low MUAC-for-age was correlated to the malaria antibody profiles. For MUAC, the two methods used to classify children as normal or low-MUAC-for-age, (based on the Cambridge and WHO reference respectively), were in agreement (kappa (k)=0.75).

Table: Demographic characteristics of the children aged 0 to 6 months and 6 to 59 months.

Variable category	*N*	*OR (95%CI)*	*p-value*
Stunting			
Age		-	<0.001
0-5	25	-	-
6-23	359	-	-
> =2Y	576	-	-
Sex F	478		
M	502	1.2 (1.0, 1.3)	0.010
Wasting			
Age		-	0.021
0-5	11	-	-
6-23	103	-	-
> =2Y	61	-	-
Sex F	107	1.7 (1.3, 2.2)	0.001
M	68		
Underweight			
Age			
0-5	36	-	<0.001
6-23	359	-	-
> =2Y	400	-	-
Sex F	412	1.1 (1.0, 1.3)	0.020*
M	383	-	-

The overall prevalence of stunting was 29.5% while in children 6-59 months it was 32.9%. The stunting prevalence started to rise from the age of 3 months onwards, and peaked in the 18-24 months children to 42.1%. From 36-59 months, the stunting prevalence remained relatively stable at 35.7% (Figure-1 & 2). Severe wasting was rare (0.6%).

The overall prevalence of underweight was 20.2%. This figure was higher i.e. 22.3% in children aged between 6-59 months. The age related pattern for underweight was similar to that observed for stunting (Figure-2).

Effects of Insecticide Treated Nets (ITN's) on Nutritional indices are summarized in Figure-1 and also reported earlier[18].

Discussion

The present study showed that children in the first 3 months of life were relatively unaffected by stunting or underweight, as their weights and heights were similar to the mean NCHS/WHO reference population. Presumably the *in-utero* experience is the main determinant of the nutritional status in this period. The Z-scores declined from 3 months onwards and reached their lowest level in the second half of the second year of life (18-23 months), and then gradually stabilized below international reference medians from the age of 30

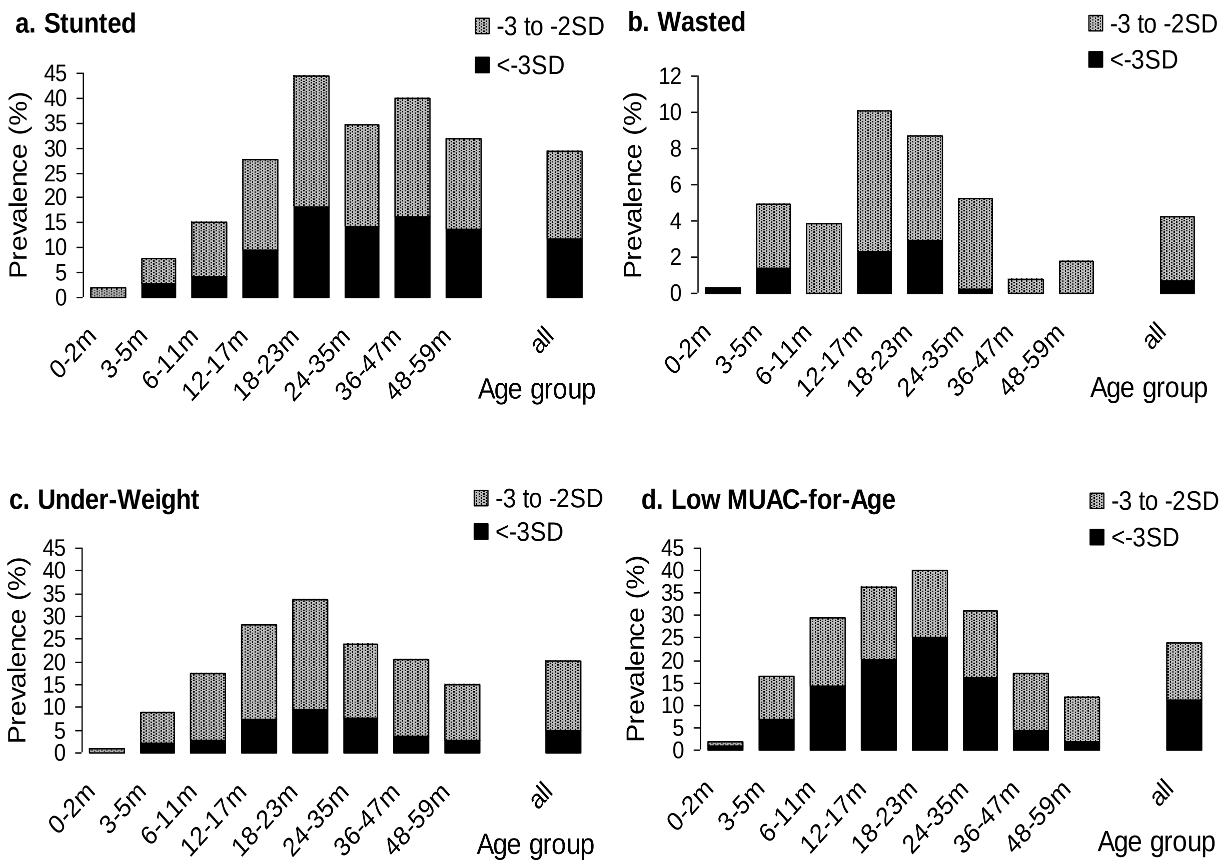

Figure 1: Prevalence of stunting (a), wasting (b), underweight (c), and low mid-upper arm circumference (d) by age group. The NCHS/WHO reference was used for figures 2a, 2b, and 2c. The Cambridge Infant Growth Study reference population was used for figure 1d.[31]

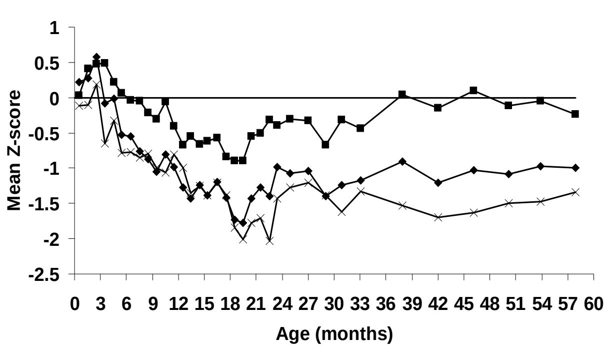

Figure 2: Age adjusted Mean Z-scores by age. Squares represent Weight-for-Height, diamonds Weight-for-age, and crosses Height-for-Age. The horizontal line at the Z-score value of 0 represents the median Z-score of the reference population. The NCHS/WHO reference was used to calculate the Z scores.

months onwards, after which little change occurred. This pattern is consistent with results from sub-Saharan Africa published by others[22]. Stunting in the younger children reflects a continuing process of failing to grow, and a state of 'having failed to grow' in older children > 3 years.[29] Stunting was most profound in this younger age group because annual growth velocities are the highest they will ever be, including peak height velocity in adolescence. Although catch up growth is possible if a child's environment improves substantially, but such is not the case in most developing countries and children remain on a trajectory below that of international reference norms.[30] Recent national surveys in Kenya have shown that there is a decrease in the prevalence of malnutrition, as measured by stunting, among preschool children between provinces within Kenya, as well as between districts.[6] The Central Bureau of Statistics recently conducted a multi-indicator cluster survey nationwide and reported 26% prevalence of for stunting in children aged 4-59 months, which was comparable with Demographic Health Surveillance conducted in 1998 (26%), which included all children aged less than five years.[6] Our results are similar to their results.

The results for risk factors and protein-energy malnutrition suggest that malnutrition is affected by gender, anthropometry, clinical signs for anemia and diarrhea.[16] The difference in weight gain before and after intervention was statistically significant but could not be conclusively attributed to use of ITN's. Use of ITN's in infancy could potentially result in sustained benefits.[18]

There were several constraints in the study. First, the study was conducted within the context of a large randomized controlled trial on permethrin treated bednets. As bednets are known to impact growth [23] all children living in villages using bednets were excluded from this analysis, which aimed to describe the prevalence of malnutrition in this community. Large scale use of bednets is recognized to exert a 'mass effect' or community effect.[12,24] Malaria morbidity was also reduced, specifically severe malarial anaemia and clinical malaria but there was no evidence for a mass effect on any of the standard nutritional parameters.

Conflict of interest: None declared.

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