Prevalence and Predictors of Underweight, Stunting, and Wasting among Children Aged 5 and Under in Western Kenya

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Summary

The health and nutritional status of children aged 5 and under was assessed in three villages in Siaya District of western Kenya. A cross-sectional survey was conducted among 121 adults and 175 children during July 2002. Primary caretakers were interviewed during home visits to assess agricultural and sanitation resources, child feeding practices, and the nutritional status of their children aged 5 years and under. Through anthropometry, the prevalence of underweight, stunting and wasting were determined: 30 per cent were underweight, 47 per cent were stunted, and 7 per cent were wasted. Predictors of undernutrition were analysed using logistic regression controlling for age, sex, and SES, and four major findings emerged. First, children in their second year of life were more likely to be underweight and stunted. Second, children who were introduced to foods early had an increased risk of being underweight. Third, up-to-date vaccinations were protective against stunting, while reports of having upper respiratory infections or other illness in the past month predicted underweight. Finally, living with non-biological parents significantly increased risk of stunting. Emphasis should be placed on current immunization, prolonging exclusive breastfeeding, and improving access to nutrient-rich foods among adopted children and their families via community-based nutrition interventions.

Introduction

Malnutrition is one of the most important underlying causes of child mortality in developing countries, particularly during the first 5 years of life.[1] A consistent, significant effect of both mid-to-moderate and severe malnutrition exists on mortality across diverse world populations.[2] Thus, when attempting to reduce child mortality, monitoring and reducing the prevalence of malnutrition in vulnerable populations is essential. The prevalence of malnutrition among preschool children can be used to determine the need for nutritional surveillance, nutritional care, or appropriate nutritional intervention programmes in a community.[3] By assessing the health status of the children in a community and identifying the most undernourished, target groups can be identified and nutritional interventions can be better designed to focus on the populations most in need.

The three main indicators used to define undernutrition, i.e., underweight, stunting, and wasting, represent different histories of nutritional insult to the child. Occurring primarily in the first 2–3 years of life, linear growth retardation (stunting) is frequently associated with repeated exposure to adverse economic conditions, poor sanitation, and the interactive effects of poor energy and nutrient intakes and infection.[4–6] Low weight-for-age indicates a history of poor health or nutritional insult to the child, including recurrent illness and/or starvation, while a low weight-for-height is an indicator of wasting (i.e., thinness) and is generally associated with recent illness and failure to gain weight or a loss of weight.[7] Knowing the levels of stunting, underweight, and wasting is important in determining the overall health of the community.

While the prevalence of undernutrition, as measured by stunting, has fallen by 14 per cent in the last two decades in developing countries, the situation has been quite different in Eastern Africa, where stunting has increased by approximately 2 per cent over the same time period.[8] With 48 per cent of preschool children affected, Eastern Africa continues to have the highest level of stunting on the continent.[8] Extreme poverty, poor soil fertility, and

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high rates of population increase have contributed to a rise in the number of stunted children and this trend is expected to continue.[8]

In Kenya, several surveys have reported the prevalence of stunting among children under 5 years of age to be 30–37 per cent.[3,8–10] However, there is a wide variation in the distribution of stunting and underweight by region. In poor, rural areas of Kenya, 44 per cent of children have been found to be stunted and 32 per cent are underweight, while among the richest populations in urban areas only 17 per cent of children were stunted and less than 10 per cent were underweight.[9] In a country where close to 70 per cent of the population resides in rural areas and poverty is a common threat, these disparities are a serious concern.[11]

The goal of the Mbosie Extended Nutrition Project (MENP) is to promote sustainable community-based activities in the areas of agriculture, nutrition, and health, with the ultimate aim of minimizing malnutrition among children aged 5 years and under in western Kenya. By involving community members in the design, planning, and implementation of the programme through leadership development, health education, agriculture promotion, and nutritional training, it is anticipated that the nutritional status of the children in the community will improve over time. The work being reported here took place during the initiation phase of the MENP within a new community.

The first aim of this study was to determine the prevalence of stunting, underweight, and wasting among children aged 5 and under in the community by obtaining their heights and weights and comparing them against a healthy reference population using the NCHS 2000 reference growth curves.[12] With this information, the most undernourished children were identified and targeted in the intervention. The second aim was to ascertain the major predictors of childhood undernutrition within the community, in the areas of household composition, health behaviors, illness, and agricultural practices, by conducting a door-to-door survey among adults in each household with children aged 5 and under.

Materials and Methods

Study area

This study took place during the rainy season (July and August) of 2002, a time when malaria prevalence was high and a rain shortage led to damaged crops and limited food production. Since it was during the pre-harvest period and food was limited, many food stores had run out. The study location was in the Ugunja Division of Siaya District in Nyanza Province, Western Kenya, approximately 70 km from Kisumu, the largest urban center in the region. The study area consisted of three adjacent villages located 1 h walk from the nearest trading center.

The study population was predominantly of the Luo ethnic group, a traditionally patrilineal subgroup of Nilotic-speaking peoples living in western Kenya around the shores of Lake Victoria. They represent the third largest ethnic group in Kenya, making up 13 per cent of the national population. Dholuo is most commonly spoken, but English and Kiswahili are taught in schools. Most members of the study population received at least a primary school education. While many men work as casual laborers, most Luo survive by subsistence crop farming, raising cattle, and fishing. Their main crops consist of corn, millet, beans, sorghum, bananas, kales, and some seasonal fruits such as papaya and mango. Most people in the study population live in compounds consisting of two to four households. The majority own their land and approximately half cultivate only an acre or less of soil.

Methods

In July of 2002 three adjacent villages were targeted for a nutritional intervention. A cross-sectional survey, which consisted of both questionnaire and anthropometric components, was conducted in all three villages over the course of 2 weeks. Investigators attempted to survey every household in the study area. Children aged 5 and under were identified and the biological mother of each child was invited to participate in an interview. When the biological mother was not available, the child's caretaker or another adult relative in the home was asked to participate. If no one was available, the interviewer continued to return to the home until an adult either agreed to or denied participation. Based on a census that was conducted during the study period, 89 per cent of the eligible children in the three villages were included. Verbal informed consent was attained and then the interview was conducted in Dholuo, Kiswahili, or English.

The interviews were conducted by 10 community health workers and volunteers. Demographic information was collected during the interview along with details on family food intakes, breastfeeding behaviors, sanitation, agriculture, and the child's health status. The community health workers and volunteers were trained to measure the heights and weights of the children using a hanging scale and measuring tape, using the CDC recommendations for anthropometric measurements.[13] Consensus was obtained by at least two members of the group before the heights and weights were recorded onto data sheets. Ninety per cent of the children had a growth-monitoring card, which was used to determine the child's age. If the card was not available, the child's age was determined through a series of probes directed at the adult members of the family. The

TABLE 1
Means, standard deviations and median z-scores for height and weight among boys and girls aged 5 and under in three villages in western Kenya

Age (months)	*n*	Mean weight (kg)	SD	Median *z*-score[a]
0–12	41	6.98	1.55	–0.61
13–24	39	9.69	1.84	–1.89
25–36	26	11.54	2.08	–1.35
37–48	28	14.21	2.32	–0.43
49–60	23	15.82	2.41	–0.23
Age (months)	*n*	Mean height (cm)	SD	Median *z*-score[a]
0–12	39	62.78	7.24	–1.47
13–24	38	74.62	6.02	–2.51
25–36	25	80.44	6.17	–2.32
37–48	28	90.65	7.55	–1.87
49–60	24	96.71	6.12	–1.91

[a]Based on the NCHS reference data.[8]

most severely undernourished children (based on weight-for-age) were examined and treated by a visiting pediatrician in order to address any immediate illnesses.

Analysis
The Epi-Info 2000 NutStat program was used for analysis of anthropometric measures. Weight, height, and age data were used to calculate weight-for-age, height-for-age, and weight-for-height *z*-scores based on the National Center for Health Statistics 2000 reference data.[12] A cut-off of –2 *z*-scores was used to define undernutrition. To protect the confidentiality of the participants, participant names were kept separately from their survey responses in a password-protected file. The two databases were linked using randomly generated numbers accessible only to the P. I. Range, consistency, and frequency checks were carried out on the quantitative data before conducting analyses. SAS 8.01 was used for data analysis.

The distribution of the variables was explored and extreme outliers (<–5 or >5 *z*-scores) were identified and removed from the dataset.[14] Frequencies were used to determine the prevalence of underweight, stunting, and wasting. The strength of the association between potential predictors (household composition, health behaviors, illness, and agricultural practices) with underweight and stunting was determined by examining the significance of the odds ratios using the Cochran–Mantel–Haenszel statistical test. Those variables that were found to be significant at the 0.05 level in the bivariate relationships were included in the logistic regression for both underweight and stunting, using a backward stepwise approach. Age, sex and socioeconomic status were forced into the model since they have been found to be significant in the literature and are potential confounders. Multicollinearity and interaction effects were evaluated for the model. Very few children in the sample were wasted ($n = 11$). The low prevalence of wasting made logistic analyses impractical and, consequently, the significance of the bivariate relationships were assessed using Fisher's Exact test.

To develop an SES measure, an exploratory factor analysis was conducted including the following variables: mother's education, father's education, parental work status, amount of land, number of goats, sheep, cows, hens, and oxen, and whether or not milk was purchased. One factor was extracted from this analysis, which measured the agricultural resources of the households and had an eigenvalue of 2.22. Specifically, the four variables that most strongly loaded on the factor were land amount, number of cows, number of goats, and number of oxen. The standardized regression coefficients for these variables ranged from 0.589 to 0.796. The second factor had a low eigenvalue (1.67) and therefore was not analysed. The continuous SES variable was standardized so that the mean was equal to zero and the standard deviation was equal to one.

Results

Sample description
Of the 175 children in the survey, 88 were boys. Heights were obtained for 154 children and weights were collected from 157 children. The mean age in the survey was 27.6 months, with a range between 9 days and 60 months. Because there was no significant difference between boys and girls in weight, height or weight-for-height, the sexes were combined for purposes of analyses. The mean heights and weights for children of different age groups are listed in Table 1 as well as the median number of standard normal deviates (*z*-scores) each age group is below the reference population. These Kenyan children are

below the reference population in both weight-for-age and height-for-age in all age groups, with the greatest deficits appearing in the 13–24-month age group.

Prevalence of undernutrition

Using a –2 *z*-score cut-off, the overall prevalence of undernourished children was either higher or consistent with levels reported in other studies:[9] 30 per cent of the children aged 5 and under were underweight (n = 47), 47 percent were stunted (n = 73), and 7 per cent were wasted (n = 11). The children in the age group 13–24 months had the highest prevalence of underweight, stunting, and wasting when compared with other age groups, with 60 per cent of children in their second year of life being stunted, 46 per cent underweight, and 10 per cent wasted. By the age of 5 these outcomes are improved, yet nearly half of the sample remain stunted.

Survey results

The extent to which household composition, health behaviors, illness, and agricultural practices predicted underweight and stunting is explored in this section. However, before examining these relationships, descriptive information on each set of predictors is provided. Tables 2 and 3 show results of the survey by categories of underweight and stunting.

Household composition. The mean number of people living in each home in the survey was 5.4 (range 2–10) with a mean number of three child dependants aged 10 and under (range 1–8). Most families (56 per cent) had only one child aged 60 months or younger, while 36 per cent had two children, and only 8 per cent had three children 5 years old or younger. Seventeen of the children, almost 10 per cent of the sample, had been orphaned and were adopted into the home. Sixty-nine per cent of the respondents were single wives, 20 per cent were co-wives, and the remaining 11 per cent were single or widowed. Ninety-two per cent of the women and 77 per cent of the men received a primary education or less.

Health behaviors. Over 90 per cent of children in this area were breastfed. During the first 3 months of life, 67 per cent of the children were breastfed, on average, less than 10 times within a 24 h period. Fifty per cent of the children (n = 78) were introduced to solid foods before they were 6 months old and over 90 per cent of respondents reported giving their newborn something besides breastmilk within the first week of birth. Water was most commonly given to 'aid digestion', 'solve stomach ache' and to supplement breastmilk. Less commonly, children were also given boiled water, glucose solution, cow milk and *uji*, a local porridge commonly used for weaning. Over 60 per cent of the respondents reported never treating their water, due to the high cost of charcoal and fuel necessary for boiling water. No one reported using u.v. light or disinfection as treatment methods. Fifty-four per cent of the children (n = 83) had up-to-date vaccinations and 90 per cent of the children had growth-monitoring cards.

Illness. Ninety per cent of the children were reported to have had a fever during the past month, 79 per cent reported having diarrhea, and 81 per cent had an upper respiratory infection. Another 52 per cent of the children were reported to have had some other type of illness within the past month, including malaria, vomiting, skin rashes, or severe headaches and stomach aches. An unusually large number of children (n = 73) were reported to have had measles within the past month. It was later determined, however, that at the same time that this study was being conducted a nationwide measles campaign was also taking place. Some respondents misinterpreted the child's reaction to the vaccination as symptoms of the disease. This misunderstanding was later clarified in a community meeting.

Agricultural practices. Over 50 per cent of the sample came from households that cultivated an acre or less of land. A mean of 10 crop varieties were grown within the past year (range 0–22), with most people growing maize, sweet potatoes, sorghum, and millet. Approximately 63 per cent of the children had access to a kitchen garden. The mean number of animals (cows, goats, oxen, sheep) found in the home was 3.13 (range 0–16), with 60 per cent of the sample owning cows, most of which were a local breed. Almost all respondents owned hens (93 per cent). Among the 30 per cent of children who lived in households where milk was collected from cows, a mean of 2.2 bottles were collected per day. However, the average household consumed just over one bottle each day. Eighty-one per cent used fertilizer, with most people utilizing a combination of compost and cow manure from their own farm. Close to 90 per cent reported storing their most abundant crop, most commonly between 1 and 4 months.

Predictors of undernutrition

Crude odds ratios were calculated to compare underweight and stunted children with all others (see Tables 2 and 3).

Household composition. Neither underweight nor stunting was associated with sex, village, mother's marital status, or father's education status. Mother's education, adoption status, family size, and child's age, however, were associated with undernutrition. Compared with mothers who had no formal education, women who had at least a secondary

TABLE 2
A comparison between underweight and not underweight children based on survey results using crude odds ratio and 95% CI

Survey variables	Underweight *n* (%)[a]	Not underweight *n* (%)[a]	Crude OR	95% CI
Prevalence among children	47 (30)	110 (70)		
Children from each village				
A[b]	14 (30.4)	32 (69.6)	–	–
B	16 (33.3)	32 (66.7)	1.14	0.48–2.72
C	17 (26.9)	46 (73.1)	0.85	0.37–1.96
Children's age (months)				
0–12[b]	11 (26.8)	30 (73.2)	–	–
13–24	18 (46.2)	21 (53.8)	2.34	1.01–5.95
25–36	9 (34.6)	17 (65.4)	1.44	0.50–4.18
37–48	6 (21.4)	22 (78.6)	0.74	0.24–2.32
49–60	3 (13.1)	20 (86.9)	0.41	0.10–1.65
Children's gender				
Male[b]	23 (29.9)	54 (70.1)	–	–
Female	24 (30.0)	56 (70.0)	1.01	(0.51–1.99)
Household composition				
More than five people in home	16 (22.2)	56 (77.8)	0.49	0.25–1.00
More than two-child family	29 (33.3)	58 (66.7)	1.44	0.72–2.90
One child:adult	18 (24.3)	56 (75.7)	–	–
Two children:adult	18 (43.9)	23 (56.1)	2.43	1.08–5.49
Three or more children:adult	11 (26.2)	31 (73.8)	1.10	0.46–2.63
Being adopted	7 (41.2)	10 (58.8)	1.78	0.63–4.76
Mother's marital status				
Married—single wife[b]	33 (30.8)	74 (69.2)	–	–
Married—co-wife	9 (27.3)	24 (72.7)	0.84	0.35–2.01
Single	5 (29.4)	12 (70.6)	0.93	0.31–2.87
Mother's education				
No formal education[b]	5 (21.7)	18 (78.3)	–	–
Primary school	34 (29.8)	80 (70.2)	1.37	(0.81–2.31)
Secondary school	8 (50.0)	8 (50.0)	1.64	(1.04–2.59)
Father's education				
No formal education[b]	3 (50.0)	3 (50.0)	–	–
Primary school	33 (31.1)	73 (68.9)	0.91	0.53–1.56
Secondary school	8 (25.8)	23 (74.2)	0.86	0.56–1.32
Post secondary	0 (0.0)	3 (100.0)	0.03	0.001–999[c]
Health behaviors				
Up-to-date immunizations	19 (22.9)	64 (77.1)	0.45	0.22–0.89
Growth monitoring card	42 (29.6)	100 (70.4)	0.84	0.27–2.61
Drink untreated water	43 (35.8)	77 (64.2)	8.38	1.10–22.61
Breastfed less than 10 times/24 h	35 (33.3)	70 (66.7)	2.00	0.83–4.80
Given food before 6 months	30 (38.5)	48 (61.5)	2.28	1.13–4.61
Fed child with hand vs. utensil	16 (39.0)	25 (61.0)	1.78	0.83–3.81
Report of illness last 30 days				
Fever	44 (31.9)	94 (68.1)	6.55	0.84–51.42
Diarrhea	38 (35.9)	68 (64.1)	3.19	1.31–7.82
Upper respiratory infection	41 (33.1)	83 (66.9)	3.10	1.01–9.46
Measles	25 (34.3)	48 (65.7)	1.56	0.78–3.15
Other illness	32 (37.7)	53 (62.3)	2.55	1.21–5.39
All	25 (44.6)	31 (55.4)	3.11	1.51–6.38
Agriculture practices				
Grow sweet potato	40 (28.4)	101 (71.6)	0.51	0.17–1.46
Grow sorghum	19 (25.7)	55 (74.3)	0.68	0.34–1.36
Grow snow peas	35 (29.6)	83 (70.4)	0.95	0.43–1.36
Grow tomatoes	10 (34.5)	19 (65.5)	1.29	0.55–3.05
Grow green banana	18 (37.5)	30 (62.5)	1.66	0.81–3.41
Grow avocado	26 (26.3)	73 (73.7)	0.63	0.31–1.26
Grow maize	46 (29.6)	109 (70.3)	0.42	0.03–6.89
Grow millet	27 (33.8)	53 (66.2)	1.45	0.73–2.89
Grow 6 or fewer varieties of crops	9 (37.5)	15 (62.5)	1.50	0.61–3.72
Own cows	28 (29.8)	66 (0.2)	0.98	0.49–1.97
Own goats	7 (23.3)	23 (76.7)	0.66	0.26–1.66
Own 2 or more varieties of animal	14 (29.9)	96 (70.1)	0.99	0.36–2.77

[a]*n*, number of children; [b]referent group; [c]unstable estimates due to small number of observations per cell.

TABLE 3
A comparison between stunted and not stunted children based on survey results using crude odds ratio and 95% CI

Survey variables	Stunted n (%)[a]	Not stunted n (%)[a]	Crude OR	95% CI
Children from each village				
A[b]	22 (46.8)	25 (53.2)	–	–
B	22 (47.8)	24 (52.2)	1.04	0.46–2.35
C	29 (47.5)	32 (52.5)	1.03	0.48–2.21
Children's age (months)				
0–12[b]	14 (35.9)	25 (64.1)	–	–
13–24	23 (60.5)	15 (39.5)	2.74	1.10–6.88
25–36	14 (56.0)	11 (44.0)	2.27	0.82–6.34
37–48	11 (39.3)	17 (60.7)	1.16	0.42–3.15
49–60	11 (45.8)	13 (54.2)	1.51	0.54–4.26
Children's gender				
Male[b]	35 (46.7)	40 (53.3)	–	–
Female	38 (48.1)	41 (51.9)	1.06	0.56–1.99
Household composition				
More than five people in home	34 (47.2)	38 (52.8)	0.98	0.52–1.85
More than two-child family	43 (50.0)	43 (50.0)	1.27	0.67–2.40
One child:adult	30 (41.7)	42 (58.3)	–	–
Two children:adult	23 (56.1)	18 (43.9)	1.80	0.83–3.88
Three or more children:adult	20 (48.8)	21 (51.2)	1.33	0.62–2.88
Being adopted	12 (70.6)	5 (29.4)	2.94	1.01–9.09
Mother's marital status				
Married—single wife[b]	50 (47.6)	55 (52.4)	–	–
Married—co-wife	15 (46.9)	17 (53.1)	0.97	0.44–2.15
Single	8 (47.1)	9 (52.9)	0.98	0.35–2.73
Mother's education				
No formal education[b]	13 (59.1)	9 (40.9)	–	–
Primary school	49 (43.8)	63 (56.3)	0.82	0.53–1.25
Secondary school	10 (62.5)	6 (37.5)	1.13	0.74–1.72
Father's education				
No formal education[b]	4 (80.0)	1 (20.0)	–	–
Primary school	51 (47.2)	56 (52.8)	0.88	0.51–1.52
Secondary school	14 (46.7)	16 (53.3)	0.92	0.61–1.38
Post secondary	1 (33.3)	2 (66.7)	0.81	0.42–1.56
Health behaviors				
Up-to-date immunizations	35 (42.2)	48 (57.8)	0.63	0.33–1.20
Growth monitoring card	67 (47.9)	73 (52.1)	1.22	0.40–3.71
Drink untreated water	59 (50.4)	58 (49.6)	1.30	0.46–3.75
Breastfed less than 10 times/24 h	48 (47.1)	54 (52.9)	0.99	0.47–2.04
Given food before 6 months	38 (49.4)	39 (50.6)	1.17	0.62–2.20
Fed child with hand vs. utensil	23 (56.1)	18 (43.9)	1.65	0.79–3.42
Report of illness last 30 days				
Fever	60 (44.1)	76 (55.9)	0.23	0.06–0.81
Diarrhea	51 (49.5)	52 (50.5)	1.32	0.66–2.65
Upper respiratory infection	59 (48.4)	63 (51.6)	1.25	0.55–2.86
Measles	33 (46.5)	38 (53.5)	0.94	0.49–1.78
Other illness	43 (52.4)	39 (47.6)	1.58	0.82–3.01
All	30 (55.6)	24 (44.4)	1.68	0.86–3.28
Agriculture practices				
Grow sweet potato	62 (44.3)	78 (55.7)	0.22	0.06–0.81
Grow sorghum	31 (41.9)	43 (58.1)	0.65	0.35–1.23
Grow snow peas	52 (44.8)	64 (55.2)	0.66	0.32–1.37
Grow tomatoes	11 (37.9)	18 (62.1)	0.62	0.27–1.42
Grow green banana	23 (47.9)	25 (52.1)	1.03	0.52–2.04
Grow avocado	44 (44.9)	54 (55.1)	0.76	0.39–1.47
Grow maize	72 (47.4)	80 (52.6)	0.90	0.06–14.65
Grow millet	37 (48.1)	40 (51.9)	1.05	0.56–1.98
Grow 6 or fewer varieties of crops	12 (54.6)	10 (45.4)	1.40	0.56–3.46
Own cows	41 (44.6)	51 (55.4)	0.75	0.39–1.43
Own goats	12 (42.9)	16 (57.1)	0.79	0.35–1.82
Own 2 or more varieties of animal	64 (47.4)	71 (52.6)	1.00	0.38–2.62

[a]n, number of children; [b]referent group.

school education were more likely to have children who were underweight (OR = 1.64; 95 per cent confidence interval, 1.04–2.59). Being adopted (i.e., not living with a biological parent) was found to be associated with stunting (OR = 2.94; 95 per cent CI, 1.01–9.09). Larger families appeared to be protective against underweight, with having five people or more in the home being protective against underweight (OR = 0.49; 95 per cent CI, 0.25–1.00). However, once the proportion of adults to children was explored, a ratio of children to adults in the household greater than one was found to be a risk for underweight (OR = 2.43; 95 per cent CI, 1.08–5.49). A significant association existed between underweight and not underweight children in their second year of life when compared with the referent group (0–12 months) (OR = 2.34; 95 per cent CI, 1.01–5.95). A similar association was found with children who were stunted and not stunted compared with the younger age group (OR = 2.74; 95 per cent CI, 1.10–6.88).

Health behaviors. A range of health behaviors was associated with undernutrion in the sample. Having up-to-date vaccinations was significantly protective of underweight (OR = 0.45; 95 per cent CI, 0.22–0.89) and suggestive of protecting against stunting (OR = 0.63; 95 per cent CI, 0.33–1.20). A significant difference existed between the different age groups, with older children being most up-to-date in their immunizations ($\chi^2 = 30.62$; $p = 0.0001$). Being exposed to untreated water (OR = 8.38; 95 per cent CI, 1.10–22.61) and having food introduced within the first 6 months of life were associated with underweight (OR = 2.28; 95 per cent CI, 1.13–4.61), but not with stunting.

Illness. Remarkably, all illness measures, except for fever and measles, were significantly associated with underweight (diarrhea, OR = 3.19, 95 per cent CI, 1.31–7.82; upper respiratory infection, OR = 3.10, 95 per cent CI, 1.01–9.46; other illness, OR = 2.55, 95 per cent CI, 1.21–5.39; and all illnesses, OR = 3.11; 95 per cent CI, 1.51–6.38), but only history of fever was associated with stunting, with fewer stunted children reporting a history of fever (OR = 0.23; 95 per cent CI, 0.06–0.81). It is thought that the high report of fever among healthier children was due to the febrile reaction experienced from measles immunization. Healthier children may have come from homes that showed more aggressive health-seeking behavior, so these children may have been more likely to have received the measles vaccination and responded with a fever.

Agricultural practices. There were weak, statistically non-significant protective associations between growing vitamin-rich crops and the risk of underweight and stunting among children. More children

TABLE 4
Adjusted odds ratios for the covariates in the final logistic model for underweight

Underweight	Covariates	Adjusted OR	95% CI
(*n* = 47)	Age: 0–12 months[a]	–	–
	Age: 13–24 months	2.93	1.04–8.52
	Age: 25–36 months	2.82	0.78–10.21
	Age: 37–60 months	0.62	0.21–1.86
	SES	0.87	0.65–1.16
	Female	1.01	0.46–2.26
	Reported URI in last month	3.62	1.06–12.35
	Reported other illness in last month	2.78	1.20–6.45
	Given food before 6 months of age	2.88	1.27–6.51

[a]Referent group.

TABLE 5
Adjusted odds ratios for the covariates in the final logistic model for stunting

Stunting	Covariates	Adjusted OR	95% CI
(*n* = 73)	Age: 0–12 months[a]	–	–
	Age: between 13–24 months	4.01	1.41–11.42
	Age: between 25–36 months	2.17	0.74–6.38
	Age: between 37–60 months	1.91	0.69–5.32
	SES	0.88	0.69–1.15
	Female	1.11	0.55–2.23
	Being adopted	4.95	1.34–18.18
	Immunizations not up-to-date	2.63	1.16–5.98

[a]Referent group.

who were from homes where crops containing vitamins A, C, and E were grown (snow peas, sorghum, and avocados) were neither stunted nor underweight. This may indicate a protective effect of these foods on young children if they were consuming these crops. Children from families who grew sweet potatoes were less likely to be stunted (OR = 0.22; 95 per cent CI, 0.06–0.81), which may be indicative of both the nutritional value of the food and the ease with which it is both grown and stored.

Final models for underweight and stunting

Results of the logistic regression of the outcome variables are shown in Tables 4 and 5. Children in their second year of life were at highest risk of both underweight and stunting when compared with children aged 0–12 months. After controlling for the other variables in the model, children aged 13–24 months were approximately three times as likely to

TABLE 6
Chi-squared estimates and p values for wasting among 11 children in survey

Wasting	Covariates	χ^2	p value
(n = 11)	Reported diarrhea in last month	4.84	0.03
	No kitchen garden	3.89	0.05
	Immunizations not up-to-date	3.55	0.11
	Drink untreated water	3.35	0.12
	Given food before 6 months old	2.44	0.12

be underweight and four times as likely to be stunted than the 0–12-month-old group (underweight, OR = 2.93, 95 per cent CI, 1.04–8.52; stunting, OR = 4.01, 95 per cent CI, 1.41–11.42). Being adopted into the home was the largest predictor of stunting. When controlling for the other variables in the model, adopted children were five times more likely to be stunted than those who were not adopted (OR = 4.95, 95 per cent CI, 1.34–18.18). No statistical association was found in SES level and adoption status (χ^2 = 4.11, p = 0.39).

Early introduction of foods was a strong predictor of underweight, with children who were given food within the first 6 months of life being almost three times more likely to be underweight than those who were first given food after 6 months (OR = 2.88, 95 per cent CI, 1.27–6.51). Having current immunizations was protective against stunting. Children without up-to-date vaccinations were more than twice as likely to be stunted than children without current vaccinations (OR = 2.63, 95 per cent CI, 1.16–5.98). Vaccination status was not related to SES (χ^2 = 6.10, p = 0.19) or sex (χ^2 = 1.61, p = 0.21). Even after controlling for vaccination and the other variables in the final model, however, upper respiratory infection (URI) or other illness within the past month, emerged as strong predictors of underweight (URI, OR = 3.62, 95 per cent CI, 1.06–12.35; other illness, OR = 2.78, 95 per cent CI, 1.20–6.45).

Wasting

Table 6 shows the variables associated with being wasted. Having diarrhea in the past month was highly predictive of wasting (χ^2 = 4.79 and p = 0.03). This may be related to the finding that more children who drank water that was not consistently treated (χ^2 = 3.35 and p = 0.12) and who were first given food during the first 6 months of life (χ^2 = 2.44 and p = 0.12) were wasted. Consistent with the results seen with stunting, there was also a protective association of up-to-date vaccinations against wasting, although statistically non-significant (χ^2 = 3.55, p = 0.11). Also, those children whose families had an easily accessible kitchen garden, in addition to the crops in the field, were less likely to be wasted (χ^2 = 3.89, p = 0.05).

Discussion

The high prevalence of undernourished children found in the three villages in this study (30 per cent underweight, 47 per cent stunted, and 7 per cent wasted) approximated the estimates seen in similar studies among some of the poorest, rural areas in Eastern Africa.[3,9] The mean heights and weights in the age groups in this population corresponded with those seen in similar populations in Kenya.[15] Children in their second year of life were found to be most at risk of underweight and stunting, with more than half of the children aged 12–23 months below the –2 median z-scores, when compared with the WHO/NCHS reference data.[12] This phenomenon has been seen among other Kenyan children, where the prevalence of stunting was approximately 8 per cent higher among children in their second year of life than the overall prevalence in a sample of children aged 6–72 months.[3]

The increased risk of undernutrition as children reach their second year of life may be due to a combination of interactive effects.[16] First, during this period, growth and nutritional status may be affected as children are being weaned from the breast. Not only do mothers lose their ability to produce enough milk to meet the nutritional demand of the growing infant, children at this age are also losing the passive immunity received from the mother.[16] In addition, since many women are the family's primary laborers in the field, they may be unable to regularly nurse their newborns while farming. As a result many mothers tend to introduce foods and liquids, such as water and porridge, to their children soon after birth as a way to control the child's hunger. Growth retardation can be further enhanced by the substitution of breastmilk with high-starch, low-protein foods and water.[16,17] Early introduction of foods, exposure to unsanitary conditions, combined with the interaction of infection can lead to poorly nourished children. Targeting mothers and educating them about healthy weaning practices, or trying to delay the introduction of liquids and foods, may help in reducing undernutrition but alternatives for healthy, inexpensive weaning foods are also urgently needed.

The prevalence of underweight and stunting among the 17 adopted children in this study were 71 and 41 per cent, respectively, compared with the prevalence of 29 and 45 per cent among those not adopted in the sample. Being adopted was strongly predictive of stunting among children in this study, indicating that adopted children are at higher risk of chronic undernutrition. The number of orphaned children is increasing due to the impact of the HIV/AIDS epidemic in many parts of Kenya, where 15 per cent of the adult population (aged 15–49 years) were infected in 1999.[9] Since it is estimated that 6–11 per cent of children less than 15 years old in sub-Saharan Africa are orphaned due to the HIV/AIDS epidemic,[21] there are larger numbers of orphaned children at risk of stunting. Thus, there is a serious need to target these children and focus on their nutritional needs. Community-based surveillance systems can be implemented as a possible measure to follow at-risk children, particularly those who are adopted, to monitor their health and nutritional status over time.

The nutritional status of the children in the sample was probably influenced by the high prevalence of recent illness. In this population we found diarrhea to be significant for wasting, and upper respiratory infections and other diseases predictive of underweight. Infections, particularly diarrheal and upper respiratory diseases, occur most frequently during the first 2–3 years of life when immunocompetence is impaired and when, at the same time, children are first being exposed to disease pathogens.[18] Infection can suppress appetite and directly affect nutrient metabolism, leading to poor nutrient utilization. In this study reports of illness during the past month were similar to prevalence rates among children in other poor rural areas in developing countries where the synergistic cycle of illness and malnutrition is common.[19]

In this study just over half of the children were up-to-date with their vaccinations, which is congruent with other reports of 48.1 per cent coverage among poor, young Kenyan children.[9] Complete and current immunizations are a public health prevention tool necessary to help combat infectious disease in developing countries. The morbidity and mortality related to measles, diarrhea, and other infectious diseases are significantly reduced with effective immunization.[20] The protective effect of current vaccinations in this study demonstrates a need to implement public health programmes that target children of all ages in remote rural areas of western Kenya where they are at the greatest risk of infection.

Besides the strong protective effect of sweet potatoes, the results demonstrated a slight, non-significant inverse association between growing vitamin-rich crops and underweight and stunting. Foods containing vitamins A, C, and E, have been shown to have protective effects on young children. However, when household income is very low, demands may necessitate the sale of nutritious items, such as milk, kales, tomatoes and green bananas, and the children may not gain access to the foods they need.[22] Maize and millet, alternatively, are two staple crops that are commonly grown and consumed by most children, regardless of resources. They are imported grains that are considered to be hardy and able to withstand drought. Unfortunately, they lack important nutrients for child growth. Consistent mono-cropping during both major growing seasons, in combination with not letting land go fallow, has led to poor soil quality, poor crop quality and meager yields for both grains. A targeted community-based nutritional intervention may be the least costly, most practical and effective alternative in improving the nutritional status of the children in the study community and others like it. Since the armory against malnutrition remains limited and many existing programmes are expensive, inefficient, and create a relationship of dependency, agriculture-based nutritional programmes, which promote vitamin-rich indigenous fruits and vegetables and other healthy foods may be a healthy, practical option.

Limitations

While this study accomplished its objectives to determine the prevalence and determinants of underweight, stunting, and wasting among children aged 5 and under, there are several limitations. First, since it was a cross-sectional design, it was difficult to examine any potential temporal relationships. The data represents a particular point in time and establishing a cause and effect relationship, therefore, can be limited. Also, like similar studies in tropical areas, this study was affected by seasonal variation and the varying availability of foods.[17] The survey was conducted during a particularly dry period, just before the harvest, when access to food was low. Concurrently, there was also a serious malaria epidemic and many children were undergoing measles vaccinations. These events may have had a significant impact on the nutritional status of the children and must be kept in mind when interpreting the data.

Some biases within the study may affect the generalizability of the results. Selection bias may exist since a small proportion (11 per cent) of the eligible children in the study area did not participate. Based on an analysis using chi-squared statistics between those children who participated in the study and those in the census who did not participate, there were no differences in age, sex, and household size. However, those who did not participate may have had children who were more sickly or undernourished and did not want to risk social stigma. There is also the possibility that families with more resources were able to send their healthy children to live with other family members in more urban areas.

There is potential recall bias among respondents answering questions relating to events happening in the past, such as the child's history of illness and breastfeeding patterns immediately after birth. There may have been some reporting bias, since the possibility exists for respondents to answer in ways that may be more socially desirable or in ways that they thought would extract a more sympathetic response from the study staff. Finally, there is the potential for information bias, since the precise age of the children was not always known and the absence of the growth-monitoring card among about

10 per cent of the sample made it difficult to determine the child's age with complete accuracy.

Information on several important confounding variables was not collected which could cause problems in interpreting the results. For example, parasitic infestation, which is widespread among youths in Africa, was not controlled for. Parasites can affect the nutrition and growth of children by depriving them of nutrients, impairing intestinal absorption of fat, nitrogen and vitamin A, and reducing food intake.[17] We also lacked important information on the mother's size and pre-pregnancy weight and the child's birthweight, all of which are strongly associated with the child's size. The exact daily caloric intake was also not ascertained, nor was HIV status.

The use of external reference data in defining underweight, stunting, and wasting is also problematic when interpreting the results. Even though the CDC and WHO recommend its use for international studies, interpretation must be cautious because it is based on an ethnically different population of children living under different circumstances. A reference growth curve from Kenya is currently unavailable, but would be a helpful contribution to the public health arena. Finally, the sample size was small when breaking down groups into different exposure categories, thereby affecting the power of the results. Since the number of children who were wasted was so small, it was difficult to identify significant predictors in the analysis due to a lack of power. Also, the number of children per age group decreased with increasing age and this is likely to be due to two contributing factors. First, close to 14 per cent of the children in the poorest areas of Kenya die by the time they reach 5 years of age and this high mortality rate may result in fewer older children in the sample.[9] Also, as children get older they are more likely to be sent away to live with relatives in urban areas.

Conclusions

Child growth is a good indicator of the nutritional and health status of both the individual and the community.[23] The aim of this study was to obtain a baseline assessment of a rural Kenyan community's health and nutritional status, in order to estimate the prevalence and predictors of undernutrition and, ultimately, to reduce the morbidity and mortality due to undernutrition among children in the survey area. Based on the results from this survey, adopted children and children in their second year of life are at increased risk of undernutrition and should be targeted early to prevent malnourishment. There is also a great need for nutritional education to target mothers' breastfeeding and weaning practices, improved sanitation to help reduce exposure to pathogens, and complete and current immunizations. Existing vaccination programmes should be expanded to reach the children routinely in remote areas. Community-based nutrition interventions, which promote agriculture skills, increase food production on limited fertile land, nutritional training, leadership development and health education, are welcome public health tools and are promising candidates in the search for a practical, inexpensive, and sustainable approach to protecting young children against malnutrition.

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