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Parasite and maternal risk factors for malnutrition in preschool-age children in Belen, Peru using the new WHO Child Growth Standards

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Child malnutrition, including wasting, underweight and stunting, is associated with infections, poor nutrient intake, and environmental and socio-demographic factors. Preschool-age children are especially vulnerable due to their high growth requirements. To target interventions for preschool-age children in a community of extreme poverty in Peru, we conducted a household survey between October 2005 and January 2006 to determine the prevalence of malnutrition and its risk factors. Of 252 children <5 years old, the prevalence of wasting, underweight and stunting was 26·6, 28·6 and 32·1 %, respectively, based on the new WHO Child Growth Standards. Risk factors for wasting were: (1) moderate–high intensity *Trichuris* infection (OR 2·50; 95 % CI 1·06, 5·93); (2) hookworm infection (OR 6·67; 95 % CI 1·08, 41·05); (3) age ($OR_{6\text{-month}}$ 1·27; 95 % CI 1·11, 1·46); (4) maternal education (secondary incomplete) (OR 5·77; 95 % CI 2·38, 13·99); and (5) decreasing maternal BMI ($OR_{1\,kg/m^2}$ 1·12; 95 % CI 1·02, 1·23). Risk factors for underweight were: (1) moderate–high intensity *Trichuris* infection (OR 4·74; 95 % CI 1·99, 11·32); (2) age ($OR_{6\text{-month}}$ 1·22; 95 % CI 1·07, 1·38); (3) maternal education (secondary incomplete) (OR 2·92; 95 % CI 1·40, 6·12); and (4) decreasing maternal BMI ($OR_{1\,kg/m^2}$ 1·11; 95 % CI 1·02, 1·21). Risk factors for stunting were: (1) age ($OR_{6\text{-month}}$ 1·14; 95 % CI 1·02, 1·27) and (2) decreasing maternal height ($OR_{1\,cm}$ 1·12; 95 % CI 1·06, 1·20). Overall, risk factors for malnutrition included both child and maternal determinants. Based on these data, locally appropriate and cost-effective dietary, de-worming and educational programmes should be targeted to mothers and preschool-age children.

Malnutrition: Preschool-age children: Survey: Peru

Child malnutrition is a serious concern in developing countries due to the high mortality and morbidity with which it is associated. Preschool-age children under the age of 5 are particularly susceptible to the adverse effects of malnutrition as they are in a vulnerable growth period with high growth requirements[1]. It is estimated that 54 % of deaths in children under 5 are associated with malnutrition[2], and that approximately 5 million children die each year due to causes that are directly or indirectly related to malnutrition[3]. Morbidity related to malnutrition can occur in infancy and childhood, as well as in adulthood, and includes adverse effects on health, cognition and behaviour[4–7].

Indicators of malnutrition include wasting, stunting and underweight, which represent different aspects or measurements of malnutrition[8]. Wasting as measured by low weight-for-height represents lower than expected body mass (tissue or fat) and is a good indicator of existing nutritional deficits. Stunting, or low height-for-age is an indicator of a reduced linear growth rate and represents a chronic state of malnutrition as it takes longer for impaired skeletal growth to become apparent. Underweight, which is measured by low weight-for-age, represents a combination of both wasting and stunting. A review of the literature lists infections, nutrition, child and family demographics, and household characteristics as risk factors for malnutrition in preschool-age children[9–14].

The reduction in the prevalence of underweight in children under the age of 5 is one of the indicators of the first Millennium Development Goal target which seeks to eradicate extreme poverty and hunger[15]. Although improvements have been made in reducing the worldwide prevalence of malnutrition, it is clear that concentrated efforts will be needed to reach the Millennium Development Goal[16], especially in areas of extreme poverty where malnutrition is highest. The identification of populations at risk has recently been improved due to the newly released WHO Child Growth Standards by which accurate estimates of indicators of malnutrition can be calculated[8]. This new standard is based on a sample of children from six countries (Brazil, Ghana, India, Norway, Oman and the USA) and represents how children between 0 and 5 years of age should grow under healthy conditions. The US National Center for

Abbreviations: NCHS, National Center for Health Statistics.

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Health Statistics (NCHS) international growth reference was previously used as a comparison; however due to methodological issues (e.g. homogeneous sample of children from the USA only, insufficient frequency of measurements) and the fact that it is a reference and not a standard (i.e. represents how children grow, not how children should grow) its generalizability is limited[17].

The objective of the present study was to determine the prevalence of three indicators of malnutrition (wasting, underweight and stunting) using the new WHO Child Growth Standards and associated risk factors in a population of preschool-age children living in an area of extreme poverty in the Peruvian Amazon.

Methods

Survey area

A household survey was conducted in the community of Belen from October 2005 to January 2006. Belen is located outside of the capital city of Iquitos in the province of Loreto in the Peruvian Amazon. Due to the seasonal flooding of the Rio Itaya, most of the houses are built on stilts or floating on wooden platforms whereby access to potable water and proper sanitation is a challenge. Belen is geographically divided into zone 'alta', or low flooding area, and zone 'baja', or high flooding area. These zones also serve to divide the community into higher and lower socioeconomic status, respectively.

Survey planning

The area boundaries within Belen with associated estimates of size (number of households) were provided by the Instituto Nacional de Estadística e Informática in Iquitos which had completed a census of Belen in August 2005. The census information delineated groupings of household blocks (called 'manzanas') within zones 'alta' and 'baja'. A strategy for choosing and sampling households was based on probability proportional to size with the household as the unit of observation and proceeded as follows: (1) blocks were listed according to zone 'alta' and zone 'baja'; (2) blocks were grouped together geographically within 'alta' and 'baja' to form clusters of approximately the same size; (3) clusters were arranged in a list in geographical order and numbered; (4) based on the average number of households per cluster and the desired sample size, clusters to be surveyed were randomly chosen; (5) all households within each cluster were then visited.

Questionnaire

The questionnaire was developed in English using the Multiple Indicator Cluster Survey 2 to assist in the formulation of survey questions and then translated into Spanish. Questions were chosen for their relevance in obtaining socio-demographic indicators as well as other variables found to be important determinants of malnutrition in previous research.

Field survey

Field teams were provided with a map of each cluster to be surveyed. Each household was visited on two consecutive days, with interviews being conducted with the female head of the household. During the first visit, households were informed of the purpose of the survey, informed consent for the participation of the household was obtained, and a container for stool specimens was given. On the second visit, the questionnaire was completed. Height and weight measurements and blood and stool samples were also collected from the interviewee and one child under 5. If two or more children under the age of 5 were present in the household, one was randomly chosen for inclusion in the study. The weight of mothers and of children able to stand alone, in light clothing and without shoes, on a digital portable scale, was measured in pounds, and converted into kilograms. For children unable to stand alone, the difference between the mother's weight and that of the mother and the child, on the digital scale, was similarly ascertained. Height, without shoes, was measured to the nearest millimetre using a measuring stick against a wall. Length for infants under 2 years of age was measured on a flat surface using a measuring tape, to the nearest millimetre. Blood samples were collected using fingerprick blood. The second drop of fingerprick blood was drawn into a microcuvette for Hb determination (g/dl) using a HemoCue® machine (HemoCue Inc., CA, USA). Fingerprick blood was also tested for malaria infection using the Giemsa stained thick and thin smear technique. The Kato-Katz technique was used to determine the presence and intensity of intestinal helminth eggs in the stool specimens.

Statistical analyses

Gender-specific anthropometric z-scores for weight-for-height, weight-for-age and height-for-age were calculated using the new WHO Child Growth Standards[18]. Moderate to severe wasting, underweight and stunting were defined as z-scores < -2 SD from the WHO Standards for weight-for-height, weight-for-age and height-for-age, respectively. Estimates of severe wasting, underweight and stunting were calculated using z-scores < -3 SD from the standards. Children who had potentially incorrect or out-of-range z-scores based on height or weight measurements were flagged by the software and excluded from analyses. For comparison, anthropometric z-scores were also calculated using the NCHS international growth reference[18]. Anaemia was defined as a Hb value $< 11{\cdot}0$ g/dl for children and $< 12{\cdot}0$ g/dl for mothers[19].

Means and frequency procedures were used to describe the individual and household characteristics of the study population. Logistic regression was used to determine risk factors for moderate to severe wasting, underweight and stunting, adjusting for potential confounders. All potential variables to be included in model building were first examined for correlations with one another. Although socioeconomic and other household information was gathered, there was a high correlation of these variables with one another and with more proximate indicators of malnutrition such as infection prevalence and other individual and maternal characteristics. The variables chosen for inclusion in model building were those that better explained the outcome in univariate analysis, or those previously determined to be more relevant from the literature. Univariate logistic regression was used to determine potential variables to be included in multivariate analyses at $P<0.20$. Variables with $P<0.05$ in the final multivariate logistic regression model were considered independent risk factors for moderate to severe wasting, underweight and stunting. Models were re-run using the generalized estimating equation to take into account the effect of clustering. All statistical analyses were performed using the Statistical Analysis Systems statistical software package version 9.1 (SAS Institute, Cary, NC, USA).

Ethics approval

Ethics approval was obtained from the Ethics Review Board of the Research Institute of the McGill University Health Centre in Montreal, Canada, and the Ministerio de Salud in Iquitos, Peru.

Results

Final population sample

Households were visited between October 2005 and January 2006. Zone 'baja' was surveyed first. It was also imperative to survey zone 'baja' before the rainy season (December to April) due to the high potential for flooding in this area. In zone 'baja', there were a total of thirty-eight clusters of households. Anticipating an average of twenty households per cluster and a total desired sample size of 220 households, a random sample of eleven clusters was selected. All eleven clusters (100 %) were sampled, with 213 households (96·8 %) participating in the survey. After completing the surveys in zone 'baja', surveys were then conducted in households in zone 'alta'. As it was apparent that there was not enough time to survey all of the anticipated households in zone 'alta', a decision was made to do systematic sampling of households based on geographical order until the available time and financial resources had been expended. In zone 'alta', there was a total of eighty-six clusters of households. Anticipating an average of thirty households per cluster and a total desired sample size of 780 households, a random sample of twenty-six clusters was selected. A total of fifteen clusters (58 %) were sampled, with 274 households (35·1 %) participating in the survey.

Of 487 participating households in zone 'baja' and 'alta', a child under 5 was present in 288 of the households. Thirty-six children were excluded from subsequent analyses for the following reasons: missing anthropometric and Hb information (*n* 1), no stool specimen obtained (*n* 21) and flagged anthropometric values (*n* 14). Therefore, our final sample size of children with complete data was 252 children.

Child characteristics

The mean age of the children was 27·5 (SD 16·2) months with a range between 0·62 and 59·6 months; 49 % were female; 12 % (*n* 30) attended preschool, all of whom were over the age of 36 months. The prevalence of anaemia was 56·0 %, and 29·4 % had had diarrhoea in the last week. For those over the age of 12 months, the recommended age by which children should be vaccinated against measles, the vaccination rate was 91·2 %. The prevalence of hookworm, *Trichuris* and *Ascaris* infections was 3·2, 38·9 and 32·1 %, respectively; 48 % of the children were infected with at least one infection of hookworm, *Trichuris* or *Ascaris*. Only one child was positive for malaria (*Plasmodium vivax*).

Maternal and household characteristics

The mean age of mothers who had children included in the present study was 28·7 (SD 7·7) years; 38 % had completed secondary education and 42·1 % were employed outside of the home. The mean BMI of mothers was 24·8 (SD 4·4) kg/m^2, which is considered in the normal range. For their last birth: 78·5 % had given birth in a hospital or health centre; the mean duration of breastfeeding (exclusive or predominant) was 15·3 (SD 7·8) months (for the 147 women not currently breastfeeding); 78·4 % had a doctor or trained obstetrical nurse to assist in delivery; and 84·1 % attended the recommended six or more prenatal visits. The characteristics of mothers and households in relation to wasting, underweight and stunting are given in Table 1.

Risk factors for malnutrition

It was found that 50 % of the children suffered from either wasting, underweight or stunting, and 27·4 % had at least two of these indicators of malnutrition (Table 2). The prevalence of moderate to severe wasting, underweight and stunting in the population of preschool-age children was 26·6, 28·6 and 32·1 %, respectively. The prevalence of severe wasting, underweight and stunting in children was 17·9, 18·3 and 11·1 %, respectively.

Risk factors for moderate to severe wasting were: (1) moderate–high intensity of *Trichuris* infection (OR 2·50; 95 % CI 1·06, 5·93); (2) hookworm infection (OR 6·67; 95 % CI 1·08, 41·05); (3) increasing age of child ($OR_{6\text{-month}}$ 1·27; 95 % CI 1·11, 1·46); (4) maternal education level (secondary incomplete *v.* secondary complete) (OR 5·77; 95 % CI 2·38, 13·99); and (5) decreasing maternal BMI ($OR_{1\,kg/m^2}$ 1·12; 95 % CI 1·02, 1·23) (Table 3).

Risk factors for moderate to severe underweight were: (1) moderate–high intensity of *Trichuris* infection (OR 4·74; 95 % CI 1·99, 11·32); (2) increasing age of child ($OR_{6\text{-month}}$ 1·22; 95 % CI 1·07, 1·38); (3) maternal education level (secondary incomplete *v.* secondary complete) (OR 2·92; 95 % CI 1·40, 6·12); and (4) decreasing maternal BMI ($OR_{1\,kg/m^2}$ 1·11; 95 % CI 1·02, 1·21).

Risk factors for moderate to severe stunting were: (1) increasing age of child ($OR_{6\text{-month}}$ 1·14; 95 % CI 1·02, 1·27) and (2) decreasing maternal height ($OR_{1\,cm}$ 1·12; 95 % CI 1·06, 1·20).

There were negligible differences in risk factors for wasting, underweight and stunting when using the generalized estimating equation method to take clustering into account (results not shown).

Comparison between National Center for Health Statistics and WHO estimates

Using the NCHS reference to calculate the prevalence of malnutrition in the present study, the estimates of moderate to

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Table 1. Prevalence of wasting, underweight and stunting with respect to household and maternal characteristics of 252 pre-school-age children, Belen, Peru, October 2005 to January 2006

	Frequency		% Wasting	% Underweight	% Stunting
	n	%	(*n* 67)	(*n* 72)	(*n* 81)
Household characteristics					
Zone					
Low flooding ('alta')	138	54·8	5·8	9·4	24·6
High flooding ('baja')	114	45·2	51·8	51·8	41·2
Sewage*					
Underground closed pipe	111	44·6	0·90	4·5	24·3
Above-ground open drain	128	51·4	48·4	47·7	39·1
None	10	4·0	40·0	50·0	30·0
Potable water					
No	22	8·7	22·7	22·7	22·7
Yes	230	91·3	27·0	29·1	33·0
Human waste disposal					
In-house toilet	103	40·9	1·94	5·83	24·3
Land-based latrine	109	43·3	37·6	39·5	40·4
Floating latrine	27	10·7	59·3	51·2	37·0
Above-ground open drain	13	5·2	61·5	69·2	15·4
Floor material					
Cement	67	26·6	1·49	4·5	25·4
Cement and earth/wood	42	16·7	9·52	14·3	23·8
Earth/wood	143	56·8	43·4	44·1	37·8
House material					
Cement	82	32·5	4·9	7·3	24·4
Cement and earth/wood	29	11·5	6·9	10·3	27·6
Earth/wood	141	56·0	43·3	44·7	37·6
Garbage disposal					
Collected	172	68·3	13·4	16·9	30·2
Above-ground open drain	56	22·2	48·2	50·0	35·7
River	24	9.5	70·8	62·5	37·5
Maternal characteristics					
Secondary education					
Complete	95	37·7	7·4	12·6	25·3
Incomplete	157	62·3	38·2	38·2	36·3
Employment outside home					
No	146	57·9	24·0	27·4	33·6
Yes	106	42·1	30·2	30·2	30·2
Place of delivery of last child					
Hospital	192	76·2	18·2	20·8	23·1
Health centre	6	2·4	50·0	50·0	66·7
Home	54	21·4	53·7	53·7	42·6
Assisted at delivery of last child*					
Trained medical	196	78·4	18·9	21·4	29·6
Other medical	38	15·2	47·4	47·4	36·8
Family	16	6·4	75·0	75·0	50·0
Attended prenatal care for last child					
Yes	212	84·1	22·6	24·1	29·7
No	40	15·9	47·5	52·5	45·0
Breastfeeding of last child (months)					
< 6	116	46·0	20·7	25·0	30·2
6–12	26	10·3	26·9	30·8	34·6
12–24	86	34·1	29·1	31·4	37·2
≥ 24	24	9·5	45·8	33·3	20·8
Anaemia†					
Yes	78	31·0	28·2	29·5	35·9
No	174	69·1	25·9	28·2	30·5
BMI‡					
Underweight	8	3·2	37·5	62·5	75·0
Normal	114	57·1	31·9	31·9	33·3
Overweight/obese	100	40·0	18·0	21·0	27·0

* Totals do not sum to 252 due to missing answers on the questionnaire.
† Anaemia: <12 g Hb/dl = yes; ≥ 12 g Hb/dl = no.
‡ Underweight = BMI $<$ 18·5; normal = BMI 18·5–24·9; overweight/obese = BMI $\geq$ 25·0.

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Table 2. Comorbidity of wasting, underweight and stunting in a population of 252 preschool-age children in Belen, Peru, October 2005 to January 2006

	Number of children (n 252)	
Malnutrition indicators*	Frequency	%
No malnutrition	125	49·6
Wasting only	13	5·2
Underweight only	3	1·2
Stunting only	42	16·7
Wasting and underweight	30	11·9
Wasting and stunting	0	0
Underweight and stunting	15	6·0
Wasting, underweight and stunting	24	9·5

* Wasting, underweight and stunting are defined as weight-for-height, weight-for-age and height-for-age < −2 SD from WHO Child Growth Standards[18].

severe wasting and underweight (25·4 and 32·5 %, respectively) were similar to those obtained using the new WHO Child Growth Standards (26·6 and 28·6 %, respectively), while a lower prevalence was found for moderate to severe stunting (23·8 and 32·1 %, respectively). For the 'severe' categories, the NCHS and WHO estimates were similar for the category of severe underweight (17·9 and 18·3 %, respectively), but the WHO estimates were higher for severe stunting (11·1 and 7·1 %, respectively) and for severe wasting (17·9 and 11·9 %, respectively).

Discussion

Although progress has been made in reducing malnutrition on a national basis in Peru[20], it is clear that not all areas have benefited from this decline. The prevalence of moderate to severe underweight in the present study population was 28·6 % which is almost three times higher than the national average in Peru from 2000[20]. The prevalence of severe underweight was more than 20 times higher than the reported national prevalence of 0·8 %. These numbers show the importance of targeting high-risk areas, such as Belen, which are not accurately reflected in national statistics. Compared to other studies of preschool-age children in Latin American countries (Table 4)[9–11,14,21,22], our estimates of malnutrition, particularly underweight and wasting, are considerably higher. Previous studies, as well as the national statistics from Peru, used the NCHS international growth reference to estimate the prevalence of malnutrition which limits direct comparability with the present results. However, regardless of the reference population chosen, the prevalences of both moderate to severe and severe malnutrition are exceptionally high in the present study population.

The present data also show that *Trichuris* and hookworm infections are important risk factors for underweight and wasting in children under 5. This is consistent with previous research[23]. Mechanisms by which helminth infection can lead to malnutrition in children include decreased appetite and food intake, depletion and impaired absorption of micronutrients, and anaemia[24]. In the short term, de-worming with a recommended broad-spectrum anthelminthic, such as single-dose albendazole or mebendazole, is necessary to cure or decrease the worm burden in preschool-age children. Previous studies have shown growth improvements in children of this age group after anthelminthic treatment[25,26]. School-based de-worming programmes are recommended by WHO in endemic areas where helminth prevalence and intensity exceed certain thresholds[27]. The present data lend support for similar interventions at the preschool-age level.

Table 3. Risk factors for wasting, underweight and stunting in a population of 252 preschool-age children in Belen, Peru, October 2005 to January 2006

Risk factor	Crude OR*	95 % CI	Adjusted OR†	95 % CI
Wasting (n 67)‡				
Moderate–high intensity *Trichuris* infection (*v.* no–low intensity)	6·82	3·26, 14·28	2·50	1·06, 5·93
Hookworm infection (yes *v.* no)	9·00	1·77, 45·74	6·67	1·08, 41·05
Moderate–high intensity *Ascaris* infection (*vs.* no–low intensity)	3·57	1·79, 7·09		
Diarrhoea in the last week (yes *v.* no)	1·65	0·91, 2·99		
Age of child (per 6-month increment)	1·32	1·17, 1·48	1·27	1·11, 1·46
Gender (female *v.* male)	1·54	0·88, 2·71		
Maternal education level (secondary incomplete *v.* Complete)	7·78	3·38, 17·91	5·77	2·38, 13·99
Maternal BMI (per 1 kg/m^2 decrease)	1·10	1·02, 1·18	1·12	1·02, 1·23
Underweight (n 72) ‡				
Moderate–high intensity *Trichuris* infection (*v.* no–low intensity)	9·22	4·25, 19·99	4·74	1·99, 11·32
Hookworm infection (yes *v.* no)	4·40	1·02, 18·93		
Moderate–high intensity *Ascaris* infection (*v.* no–low intensity)	5·10	2·54, 10·23		
Age of child (per 6-month increment)	1·28	1·15, 1·43	1·22	1·07, 1·38
Gender (female *v.* male)	1·46	0·84, 2·53		
Maternal education level (secondary incomplete *v.* complete)	4·28	2·16, 8·49	2·92	1·40, 6·12
Maternal BMI (per 1 kg/m^2 decrease)	1·10	1·03, 1·18	1·11	1·02, 1·21
Stunting (n 81)‡				
Moderate–high intensity *Trichuris* infection (*v.* no–low intensity)	1·90	0·94, 3·83		
Age of child (per 6-month increment)	1·13	1·02, 1·24	1·14	1·02, 1·27
Maternal education level (secondary incomplete *v.* complete)	1·69	0·96, 2·97		
Maternal height (per 1 cm decrease)	1·12	1·05, 1·19	1·12	1·06, 1·20

* All variables with a $P<0·20$ were included in the multivariable model.
† All models control for child gender (male or female) and maternal age.
‡ Wasting, underweight and stunting are defined as weight-for-height, weight-for-age and height-for-age < −2 SD from WHO Child Growth Standards[18].

Table 4. Prevalence of wasting, underweight and stunting in previous cross-sectional studies in preschool-age children in Latin America and the Caribbean*

Reference	Location	Age	Sample size	Prevalence (%)†		
				Wasting	Underweight	Stunting
Ferrari *et al.*, 1998[21]	Brazil	0–72	233	0·4	7·7	17·6
Hernandez-Diaz *et al.*, 1999[9]	Mexico	0–59	4663			18·8
Nestel *et al.*, 1999[10]	Honduras	12–71	1725	1·5	24·5	38·5
Marins & Almeida, 2002[11]	Brazil	0–59	2194	2·8	4·2	6·8
Aerts *et al.*, 2004[13]	Brazil	0–59	3389			6·8
Bronte-Tinkew & DeJong, 2004[22]	Jamaica	0–59	765			9·4
Sakisaka *et al.*, 2006[14]	Nicaragua	0–23	756	5·0	10·3	30·1
Casapía *et al.*, 2007 (present study)	Peru	0–59	252	26·6	28·6	32·1

* All prevalences of malnutrition are based on the US National Center for Health Statistics reference population.
† Blank cells indicate outcomes that were not measured.

The increasing risk of malnutrition with age shows that malnourished children continue to deviate from expected growth standards as they get older. Previous studies demonstrated that preschool-age children are in a vulnerable growth period[6,9,11,12,28–30] and that interventions are needed to improve their nutritional state. With the increasing risk of malnutrition with age, these children should be targeted before entering school so that they do not face the longer-term educational, behavioural and physical consequences of adverse health in school age.

Maternal factors, such as educational achievement, BMI and height were also found to be important risk factors for wasting, underweight and stunting in children under 5 years of age. This highlights the importance of targeting families in addition to individual children in order to have a greater reduction in child malnutrition. Maternal education has been previously found to be an important risk factor for child malnutrition[9–11,14,31]. There are various direct and indirect ways by which maternal education can affect malnutrition in children. Mothers who are more educated may have better knowledge of proper health and nutrition behaviours for their family, including breastfeeding[32]. They may also be more likely to attend prenatal care and therefore be exposed to healthy pre- and post-pregnancy behaviours for themselves and their newborns. This would be an appropriate time-point for the health services to provide targeted information on healthy nutrition for both mother and child, which could be especially important for mothers with a lower level of formal education. In addition to educational level, maternal BMI and height were found to be risk factors for wasting, underweight and stunting. This is consistent with the mechanism of malnutrition in which mothers who are malnourished are more likely to have children of low birth weight, who are themselves more likely to suffer from wasting, underweight and stunting in childhood and adulthood. This finding also corroborates previous research in this area[9].

Strengths of the present study include: (1) the use of a recent census of Belen for sampling methodology; (2) the collection of a wide range of potential confounding variables such as socio-demographic information and other family and maternal characteristics; (3) the use of the new WHO Child Growth Standards[18] to give accurate estimates of the prevalence of malnutrition in this population; and (4) calculation of risk factors for wasting which has been difficult in previous studies due to low sample sizes. Limitations include: (1) the use of the survey design which limits the determination of the direction of cause and effect of the outcome and potential risk factors; (2) not having information on birth weight which has been shown to be a strong predictor of growth in childhood[11,30]; and (3) not surveying all of the clusters in zone ‘alta’ which may have limited the representativeness of the final study population.

Overall, the results show that both individual and family characteristics are related to the occurrence of malnutrition in preschool-age children. The literature highlights the potential for reducing or reversing malnutrition through individual and macro-level interventions[26,33–36]. In the short term, health and nutrition educational interventions targeted to mothers and children, and de-worming and dietary programmes for preschool-age children are needed. As these children would not yet be attending primary school and most do not attend preschool, it is important to target these children and their families through alternate means. For example, interventions for mothers could occur during prenatal and postnatal care to ensure that they are properly educated about good health and nutrition behaviours for themselves and their families. A combination of interventions may be most effective[36]. It should be noted, however, that nutrient intake was not rigorously assessed in the present study and that future research should include a more comprehensive analysis of nutritional risk factors for wasting, underweight and stunting.

If the Millennium Development Goals are to be reached, extra efforts are needed to target vulnerable populations, such as those in areas of poverty or rural areas, or who otherwise do not have easy access to existing interventions or health services. Otherwise, continued health inequalities within countries will persist and high-risk individuals, even in countries with favourable Millennium Development Goal indicators, will be neglected. Long-term and sustainable solutions for combating child malnutrition require a strong commitment from government, non-governmental organizations, community groups and families. Future research should determine the cost-effectiveness of both short- and long-term interventions for child malnutrition, especially in vulnerable populations such as those living in areas of extreme poverty.

Conclusions

The community of Belen has long been neglected in terms of research attention and programmes to improve health and

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reduce poverty. It is clear that statistics of malnutrition at the national level in Peru are not representative of this community and likely other similar communities of extreme poverty. The present study provides a recent and accurate picture of the prevalence of wasting, underweight and stunting in pre-school-age children in Belen and highlights the importance of both individual and family-based risk factors associated with malnutrition. This information can be used by the health authorities in the area to target appropriate health and education interventions, as a minimum, to pregnant women, new mothers and infants. The results of the present study will contribute not only to ensuring attention for the community of Belen, but also other communities of extreme poverty in Peru and elsewhere.

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