Predicting Undernutrition at Age 2 Years with Early Attained Weight and Length Compared with Weight and Length Velocity

Catherine Schwinger, MA[1], Lars T. Fadnes, PhD[1,2], Sanjaya K. Shrestha, MD[1,3], Prakash Sundar Shrestha, MD[4], Ram Krishna Chandyo, PhD[4], Binob Shrestha, BPH[3], Manjeswori Ulak, MD[4], Ladaporn Bodhidatta, MD[5], Carl Mason, PhD[5], and Tor A. Strand, PhD[1,6]

Objective To estimate the abilities of weight and length velocities vs attained growth measures to predict stunting, wasting, and underweight at age 2 years.

Study design We analyzed data from a community-based cohort study (The Etiology, Risk Factors, and Interactions of Enteric Infections and Malnutrition and the Consequences for Child Health and Development study [MAL-ED] study) in Bhaktapur, Nepal. A total of 240 randomly selected children were enrolled at birth and followed up monthly up to age 24 months. Linear and logistic regression models were used to predict malnutrition at 2 years of age with growth velocity z scores at 0-3, 0-6, 3-6, 6-9, 6-12, and 9-12 months (using the World Health Organization Growth Standards) or attained growth at 0, 3, 6, and 12 months as predictors.

Results At age 2 years, 4% of the children were wasted, 13% underweight, and 21% stunted. Children who were malnourished at age 2 years had lower mean growth z scores already at birth and throughout the study period. Anthropometric indicators in infancy were significant predictors for growth at the age of 2 years during most periods and at most ages in infancy. Weight-for-age z score, length-for-age z score, and weight-for-length z score at age 12 months had excellent areas under the curve (91-95) to predict the value of the same indicator at age 24 months. Maximum area under the curve values for weight and length velocity were somewhat lower (70-84).

Conclusions Growth measured at one time point in infancy was better correlated with undernutrition at age 2 years than growth velocity. *(J Pediatr 2017;182:127-32).*

The first 1000 days of life, starting from conception until around the child's second birthday, increasingly are recognized as essential for child growth, with inadequate growth often indicating serious and potentially irreversible consequences.[1-5] Childhood undernutrition is estimated to contribute to 45% of all the deaths of children younger than 5 years globally[6]; however, early anthropometric deficits also are associated with long-term consequences for health and educational attainment, extending into adulthood and even into the next generation.[3,4,7-9] Thus, the first 1000 days have been suggested to be critical for the prevention of malnutrition.

Any measure of inadequate attained growth used for identifying children at risk of adverse events has the inherent limitation that the child already is stunted or wasted to a varying degree, impeding possibilities for prevention and impacts of nutritional interventions. Longitudinal growth measures such as weight velocity or weight gain have a theoretical advantage as they present a picture of the current growth trend, whereas attained growth is a cumulative measure of an altered growth rate that leads to a recognizable malnourished state.[10,11] Few studies have estimated the extent to which measures of longitudinal growth early in life can predict future nutritional status. Although weight at 12 months predicted stunting at 36 months equally well as weight gain from 3 to 6 months in children living the Republic of Congo,[12] the detection at an earlier age with weight gain could be advantageous. Iannotti et al[13] found that weight gain during the first month of life predicted attained weight and length at 1 year of age, but they did not compare it with attained growth measures. In a study in Peru, no advantage of weight gain assessment to predict underweight at 24 months of age was found compared with attained weight assessment.[11] Length gain was not found predictive of wasting or stunting at later ages in Peru and Guatemala.[11,14] These studies

AUROC	Areas under the receiver operating characteristic curves
LAZ	Length-for-age z score
LVZ	Length velocity z score
MAL-ED	The Etiology, Risk Factors, and Interactions of Enteric Infections and Malnutrition and the Consequences for Child Health and Development study
WAZ	Weight-for-age z score
WHO	World Health Organization
WLZ	Weight-for-length z score
WVZ	Weight velocity z score

From the [1]Centre for International Health, Department of Global Public Health and Primary Care; [2]Department of Clinical Dentistry, University of Bergen, Bergen, Norway; [3]Research Unit, Walter Reed/Armed Forces Research Institute of Medical Sciences, Kathmandu, Nepal; [4]Department of Child Health, Institute of Medicine, Tribuhvan University, Kathmandu, Nepal; [5]Department of Enteric Diseases, Armed Forces Research Institute of Medical Sciences (AFRIMS), Bangkok, Thailand; and [6]Department of Research, Innlandet Hospital Trust, Lillehammer, Norway

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all had different approaches to define weight and length gain.

The World Health Organization (WHO) published growth velocity standards in 2009,[15] offering the opportunity to score weight and length gain according to age and sex. Two studies have used the WHO growth velocity standards to assess the relationship with future nutritional status, but one focused on the association with obesity and did not compare the predictive ability of weight velocity with other growth measures,[16] and the other studied children with cystic fibrosis in the US.[17] Studying growth velocities could help to identify critical time windows for prevention or early interventions of undernutrition.[7,8,18] We therefore aimed to estimate the abilities of weight and length velocity z scores in infancy (according to the WHO Child Growth Standards) to predict stunting, wasting, and underweight at the age of 2 years and compare them with those of the attained growth measures weight-for-age z score (WAZ), length-for-age z score (LAZ), and weight-for-length z score (WLZ).

Methods

The Etiology, Risk Factors, and Interactions of Enteric Infections and Malnutrition and the Consequences for Child Health and Development study (MAL-ED) was conducted in 8 countries (Bangladesh, Brazil, India, Nepal, Pakistan, Peru, South Africa, and Tanzania). For this analysis, data from the Nepal site were used. The study in Nepal was carried out in the Bhaktapur municipality, located 15 km east of the capital Kathmandu and at about 1400 m above sea level. Bhaktapur had a population of about 78 000 people in 2010.[19] Hinduism and Buddhism are the predominant religions practiced in this municipality, and community members are primarily distinguished by the traditional caste system. Tourism and agriculture are the main sources of livelihoods. The climate is humid subtropical, with a hot and wet monsoon season from May to September and a cool and dry season from October to March. A pilot study in 2010 of 100 households with children 24-36 months of age showed that although socioeconomic indicators compared favorably with national averages, 40% of children were stunted.[19]

The MAL-ED study is a prospective cohort study. During enrollment from June 2010 to February 2012, 668 deliveries were recorded, with 97% occurring at the hospital. Deliveries outside the hospital were registered by fieldworkers surveying the households. Households with recent deliveries were selected randomly on a weekly basis. The number for children selected each week was based on a prestudy census, which informed the expected birth rate, and the target sample size defined for all 8 sites of the MAL-ED study (ie, to arrive at >200 children enrolled during a period of 2 years).[20]

With this weekly number, 275 children were selected, and all caretakers of were informed about the MAL-ED study. If informed consent was given, households were screened for enrollment. Participants were excluded if the family had plans to move out of the catchment area for >30 consecutive days during the first 6 months of follow-up; the mother was <16 years of age; the mother had another child already enrolled in the MAL-ED study; the child was not a singleton (ie, twins, triplets); the child's guardian failed to provide signed informed consent; weight at birth or enrollment was <1500 g; or the infant had any of the following indications of serious disease: hospitalization for something other than a typical healthy birth; severe or chronic condition diagnosed by a medical doctor (eg, neonatal disorder; renal, liver, lung, and/or heart disease; congenital conditions); or enteropathies diagnosed by a medical doctor. In total, 240 children were enrolled. Ethical approval for the study was obtained from the Nepal Health Research Council and the Walter Reed Institute of Research (Silver Spring, Maryland). All caretakers of the participating children provided informed consent. This subanalysis was approved by the Central Board of the MAL-ED study.

At enrollment (within 17 days after delivery), well-trained fieldworkers interviewed caretakers on the child's date of birth, birth weight (available for 97% of the children), breastfeeding status, and sociodemographic characteristics of the household and took anthropometric measurements using standardized techniques (length, weight, and head circumference). Thereafter, monthly anthropometric measurements were taken until the age of 2 years, resulting in 24 anthropometric measurements for each child. Length was measured with a standard length board (ShorrBoard; Weigh and Measure, LLC, Olney, Maryland), weight with an infant scale (seca, Chino, California), and head circumference with a nonstretch synthetic tape (seca). Each month a supervisor duplicated 10% of the measurements within 24 hours. The interobserver technical error of measurement for these repeated measurements was 0.343 for height and 0.070 for weight.

Data Management and Statistical Analyses

If concern or suspicion was articulated during measurements, raw values were plotted on growth curves. In case of implausible discrepancies to the previous values, measurements were redone immediately. All data were double-entered into a local database, and discrepancies and completeness were checked by the site data entry supervisor. If necessary, remeasurements were taken within the shortest time possible, generally within 2 days. Data were sent to and stored at the Data Coordinating Center at Fogarty International Center (Bethesda, Maryland), which did an external quality control and marked values that exceeded plausible ranges within subsequent measurements (increments >1.5 kg for weight, >3.5 cm for length, and >2 cm for head circumference) for review by the study site. The Data Coordinating Center made Web-based issue logs available to the local teams to enable prompt corrections. In addition, monthly reports provided the sites with feedback on data quality.

Data were analyzed with Stata (version 13; StataCorp LP, College Station, Texas). We calculated WAZ, WLZ, LAZ, weight velocity z score (WVZ), and length velocity z score (LVZ) according to the WHO Child Growth Standards.[15,21] We defined wasting, stunting, and underweight as z score ≤−2 for WLZ, LAZ, and WAZ, respectively.