Full Length Research Paper

Global positioning system mapping of growth status in Rural Honduran Children ages 6 to 60 months

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Utilizing randomly selected households of rural Honduran children ages 6 to 60 months, the objectives of this study were to determine 1) prevalence of stunting, wasting, and underweight, 2) factors associated with undernutrition, and 3) to geographically map prevalence's of stunting and underweight by health center using latitude and longitude obtained via Global Positioning System (GPS). Randomized cross-sectional household surveys were conducted in 16 health centers in southwestern Honduras. Latitude, longitude and altitude were obtained at the household using a GPS. Geographic Information Systems—ArcGIS ® 9.2 software was used to create a series of maps of stunting and underweight by health center. 851 children participated and 56.8%, 20.8%, 1.6% of the children were stunted, underweight, and wasted, respectfully. Stunting and underweight were significantly associated with increasing age and altitude. Wasting decreased with increasing age. 57% of children were identified as having one, two, or all three of the growth deficiencies. Socioeconomic status indicators were significantly associated with stunting, underweight and wasting. Within the health centers of Hornitos, Cedritos, Mateo, and Arenalitos stunting was significantly more prevalent than that of the overall population and underweight was significantly higher in Hornitos, Cedritos, and Mateo. Wasting was significantly more prevalent in Santiago de Puringla and Hornitos. This is the first study reporting GPS mapping of the prevalence of stunting and underweight by health center in Honduras. Overall the prevalence of stunting is considered very high, underweight as high and wasting is low. Areas with the highest prevalence of undernutrition, mapped by health region, can be utilized by the Ministry of Healthy and other agencies to prioritize supplemental nutrition and education programs to areas at highest risk.

Keywords: stunting, wasting, underweight, malnutrition, mapping, GPS, socieoeconomic status, Honduras, underweight

INTRODUCTION

Childhood malnutrition is the underlying cause of an

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estimated 35% of all deaths among children less than five years of age (World Health Organization (WHO) Statistics, 2012). Growth is a measure of physical development of children and anthropometric measurements are used to assess growth status and

classify undernutrition (WHO, 1997; WHO, 2006; WHO and United Nations Children's Fund (UNICEF), 2009). In 2011, an estimated 165 million children under five years of age worldwide were stunted and an estimated 101 million were underweight (UNICEF, WHO and World Bank (WB), 2012). Although the prevalence's of stunting and underweight among children under five years of age worldwide have decreased since 1990, overall progress is insufficient and millions of children remain at risk (UNICEF, WHO and WB, 2012).

Malnutrition is the underlying cause of 53% of deaths related to pneumonia, diarrhea, malaria, neonatal pneumonia and sepsis, preterm delivery, and asphyxia at birth (Bryce et al., 2005). Growth retardation is related to high mortality rates, impaired mental development, significant functional impairment and decreased cognitive performance resulting in loss of economic efficiency (United Nations Administrative Committee on Coordination (ACC)/Sub-Committee on Nutrition (SCN), 2000; Mendez and Adair, 1999). Good nutrition is essential to human development and adequate nutrition promotes cognitive achievement and early school enrollment as well as slows down or prevents the onset of chronic diseases in later life (ACC/SCN, 2000). One of the global targets is a 40% reduction of children under five years of age who are stunted by 2025, compared to the baseline of 2010 (UNICEF, WHO and WB, 2012).

Research has identified distinct geographical patterns in the prevalence of undernourished children (Nube and Sonneveld, 2005). These patterns include agronomic and climatic conditions as well as population density and integration of the economy. It has been identified that these disparities are not limited to regional/country borders (Nube and Sonneveld, 2005).

Honduras is a Central American nation with approximately 8 million people. Poverty in the country affects 60 per cent of the population, while 36 per cent live under extreme poverty conditions (International Fund for Agricultural Development (IFAD), 2012). The Republic of Honduras is the second poorest country in Central America (IFAD, 2012) with an infant mortality rate of 24.3% (Pan American Health Organization (PAHO)/WHO, 2012). It ranks 120 out of 186 countries on the United Nations Development Programme's 2013 Human Development Index – a comparative measure of life expectancy, literacy, education and standards of living for countries worldwide. (United Nations Development Programme (UNDP), 2013). Honduras is considered to be in the lower middle income category as determined by the World Bank's income classifications (UNICEF, WHO and WB, 2012).

Socioeconomic inequality in childhood malnutrition exists within developing countries with stunting and wasting disproportionally affecting the poor (Van de Poel et al., 2008). Recent reports indicate the prevalence of stunting in Honduras is 29%, wasting is 1% and underweight is 8% (children under five years of age)

(UNDP, 2013; WHO, 2012; UNICEF, 2012). Trends in the prevalence of stunting within Honduras have remained relatively static (de Onis et al., 2000). All forms of malnutrition result in significant socioeconomic and health burdens for developing countries (United Nations System Standing Committee on Nutrition, 2006).

Utilizing randomly selected households of rural Honduran children ages 6 to 60 months, the objectives of this study were to determine 1) prevalence of stunting, wasting, and underweight, 2) factors associated with undernutrition, and 3) to geographically map prevalence's of stunting and underweight by health center using latitude and longitude obtained via Global Positioning System (GPS).

MATERIAL AND METHODS

Design

Randomized cross-sectional household surveys of families with children ages 6 to 60 months were conducted in 16 health centers in southwestern Honduras. A transdisciplinary team of physicians, registered dietitians, nurses, translators, community health workers and other medical support personnel worked in collaboration with the Honduran Ministry of Health to complete child assessments within rural mountainous areas of southwestern Honduras. The health regions were selected by the Honduran Ministry of Health since they were considered areas at high risk for malnutrition and because of the difficulty of obtaining accurate and representative nutritional data.

Data Collection

Children are registered at the local public health center and detailed vaccination records are kept for each child. From these vaccination records (of children ages 6 to 60 months) 10% of the households from each health center jurisdiction were randomly selected. If more than one child at the household was between the ages of 6 and 60 months, an index child was randomly selected. Households from 149 villages and 16 health centers were invited to participate. Team members were provided training on the recognition of malnutrition through physical exam findings, anthropometric equipment, GPS device, questionnaires, interpretation of standard measurements, and treatment procedures. The study was explained to parents/guardians with the aid of a pictorial handout. Upon obtaining informed consent, the questionnaire was administered. The questionnaire, which took 15 to 20 minutes to complete, was developed with input from the Honduran Ministry of Health and obtained information concerning nutrition, health, demographics, and socio-economic status of the

household.

Height was obtained for children $\geq$ two years of age and length was obtained for children < two years of age and was acquired using the Infant/Child Shorrboard (Shorr Productions, Olney, MD). Measurements were taken to the nearest 0.1 cm. Weight was obtained to the nearest 10th of a kg using a Seca scale (Seca, Vogel and Halke, Hammer Steindamm 9-25, Hamburg, Germany). If the child was not able to stand on his or her own or otherwise would not stand on the scale, he or she was held by a family member or team member and weighed using tare weight.

Outcome Measurements

World Health Organization standards were used to evaluate anthropometrics for identification of nutritional risks (WHO Anthro, 2011). Anthropometric indictors used for these assessments were height/length, weight, gender, and age. Stunting (height for age), wasting (weight for height), and underweight (weight for age) were defined using < -2 z-scores (WHO Multicentre Growth Reference Study Group, 2006; WHO, 2006). A z-score < -3 was considered severe (WHO, 2009). Children determined to be malnourished by anthropometrics or physical exam findings at the household were referred to their local health center for further care.

Mapping

With the assistance of local community healthcare workers and community members, teams traveled to the randomly selected households to complete the assessment process. Longitude, latitude, and altitude were obtained at each house using a Garmin eTrex Vista CX GPS. The GPS units' horizontal accuracy is about 0.01 kilometer. A systematic distance error of maximum 1.6 kilometers was applied to those collected GPS points with missing decimal information. The nutritional markers of stunting and underweight were mapped for each child by latitude and longitude of the household by heath center.   Health center boundaries were estimated by including all clustered points. Geographic Information Systems—ArcGIS ® 9.2 software was used to create a series of maps. The data, used in the mapping process, were based on Media Kit—Environmental Systems Research Institute, Inc. (ESRI) Data and Maps of 2005 (i.e., country boundaries, political boundaries) and a set of GPS data in decimal degree (i.e., randomly selected participant locations by health centers). The ESRI data was used as a reference to integrate all data sets into the same geographic coordinate system—the World Geodetic System of 84 (WGS 84).

Statistical Analysis

The collected data from the household surveys were entered into the computer, verified for accuracy, and analyzed using the Statistical Package for the Social Sciences (SPSS 19.0 Chicago, IL) software. Results were considered significant at P<.05. Stunting, wasting, and underweight were calculated by the WHO standards using the WHO Anthro software (WHO Anthro, 2011).

The Offices of Research, Uniformed Services University of the Health Sciences, Bethesda, MD; Wilford Hall Medical Center, San Antonio, TX; and South Dakota State University, Brookings, SD, in addition to the Honduran Ministry of Health, approved this project. The study was coordinated through the Honduran Ministry of Health, regional health centers, and the Honduran medical liaison officers at Joint Task Force Bravo, Medical Element, Soto Cano, Honduras.

RESULTS

853 families were invited to participate and two families refused. Of the 851 participating children, latitude and longitude were available for all households. 428 males (50.3%) and 423 females participated. Mean age was 31.95 $\pm$ 14.58 months (min 6.12 mo.; max 59.93 mo.). Mean household altitude was 4642.44 $\pm$ 793.32 feet. Weight was missing for 2 children. 56.8% of children were stunted, 1.6% were wasted, and 20.8% were underweight (Figure 1).   According to the WHO classification for assessing severity of malnutrition by prevalence ranges among children under 5 years of age, the prevalence of stunting within this study is considered very high, underweight is high and wasting is low (WHO, 1997).

There were no significant differences between the prevalence of stunting, wasting, or underweight between genders.   Child age was significantly associated with growth status. As the child's age increased, prevalence of stunting (P<.001) and underweight (P<.001) significantly increased.   On the contrary, as age increased the prevalence of wasting significantly decreased (P=.004).

The total number of children identified as having one, two, or all three of the nutritional deficiencies was 487. The relationship of the co-occurrence of the children's growth parameters is shown in Figure 2. Of the 487 children 63% (n= 309) were stunted only, 33% (n=162) were stunted and underweight, 2% (n=11) were stunted, wasted, and underweight, .4% (n=2) were wasted and underweight, .4% (n=2) were underweight only, and .2% (n=1) were wasted only. Of the 14 children that were wasted, 79% of these were also stunted (n=11) and 93% were also underweight (n=13). Of the 177 children that were underweight, 98% of these were also stunted
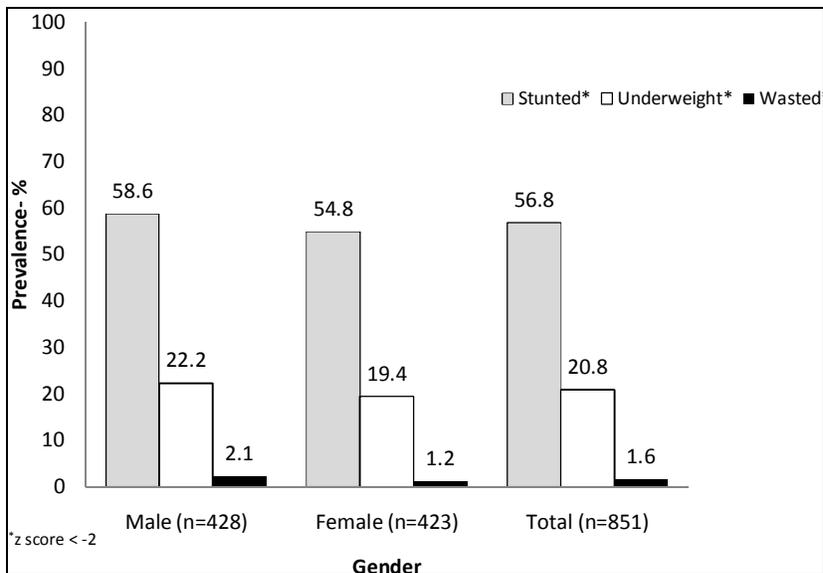
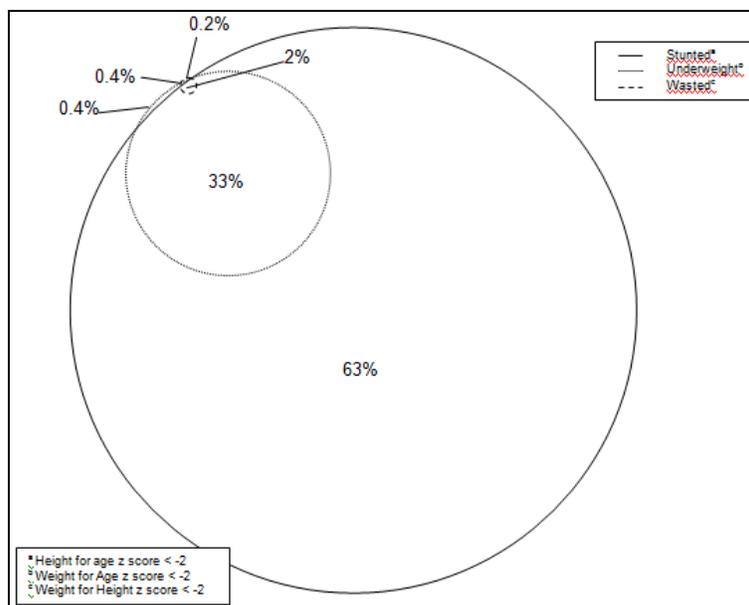**Figure 1.** Prevalence of Stunting, Underweight and Wasting in Honduran Children Ages 6 to 60 months

Figure 2. Relationship of the Co-occurrence of Stunting, Underweight and Wasting in Honduran Children Ages 6 to 60 Months (n=487)

(n=173).

All households are assigned to a local health center based on their location. Discrepancies between health centers and nutritional markers were analyzed to identify which areas have the highest prevalence of stunting, wasting and underweight by health center (Table 1). The socio-economic status indicators significantly associated with stunted, underweight and wasted are shown in Table 2.

Within the health centers of Hornitos, Cedritos, Mateo, and Arenalitos, stunting was significantly more prevalent than that of the overall population P=.011, P=.020, P=.022, and P= .041, respectively. The health center of Lepatarique had significantly less stunting when compared to the overall population (P=.001). Underweight, was significantly higher in the health centers Hornitos (P=.001), Cedritos (P=.027), and Mateo (P=.002). Wasting was significantly more prevalent in Santiago de Puringla (P=.046) and Hornitos (P=.015) than the overall sample population.

Table 1. Prevalence of Stunting, Underweight and Wasting in Honduran Children Ages 6 to 60 Months by Health Center

Health Center	Stunted (%)	Underweight (%)	Wasted (%)
Santiago de Puringla (n=98)	64	24	4*
Hornitos (n=51)	75*	39*	6*
Cedritos (n=40)	75*	35*	0
El Ocotal (n=30)	47	20	0
Lepaterique (n=167)	44*	18	1
Las Tablas (n=62)	61	23	0
Mateo (n=10)	100*	60*	0
Culguaque (n=34)	62	15	3
Mulhuaca (n=27)	41	7	4
La Estancia (n=29)	55	7	0
Chinacla (n=109)	51	20	0
Santa Maria (n=92)	55	21	2
Arenalitos (n=13)	85*	8	0
Miratoro (n=20)	70	15	0
Planes (n=57)	51	16	2
San Jose (n=12)	67	8	0
Total (n=851)	57	21	2

*Indicates significant difference from total population using Chi-Square test of association, significance at level P<.05

Table 2. Socio-economic Indicators Significantly Associated with Stunted, Underweight, and Wasted in Honduran Children Ages 6 to 60 months

Variable	Stunted	Underweight	Wasted
Age $\geq$ 24 months	<.001	NS*	.004
Mom < 6 years school	<.001	<.001	NS
Dad < 6 years school	<.001	.002	NS
Distance to health clinic > 1 hour	<.001	NS	NS
No Latrine	.005	NS	NS
Availability of piped water	<.001	.024	NS
Type of walls	<.001	NS	0
Type of floor	<.001	<.001	NS
Electricity	<.001	<.001	NS
Telephone	<.036	NS	NS
Television	.015	NS	NS
Radio	NS	.011	NS
Ever breastfed	NS	NS	.029
Mother's can read	<.001	.015	NS
Father's can read	.003	<.001	NS
2 or less rooms	<.001	.003	NS
More than 7 living in household	.012	NS	NS
Child < age 5 died in family	.046	NS	NS

NS=Not Significant (P>.05)

Analysis of covariance (ANCOVA) was used to identify significant effects between altitude and the continuous dependent variables; length for height z-scores, weight for age z-scores, and weight for length z-scores. The ANCOVA model adjusted for the additional covariates of health center, age and gender. Results from this test indicate that altitude is significantly associated with stunting (P< .001) and underweight (P=.013), but is not significantly associated with wasting (P=.842).
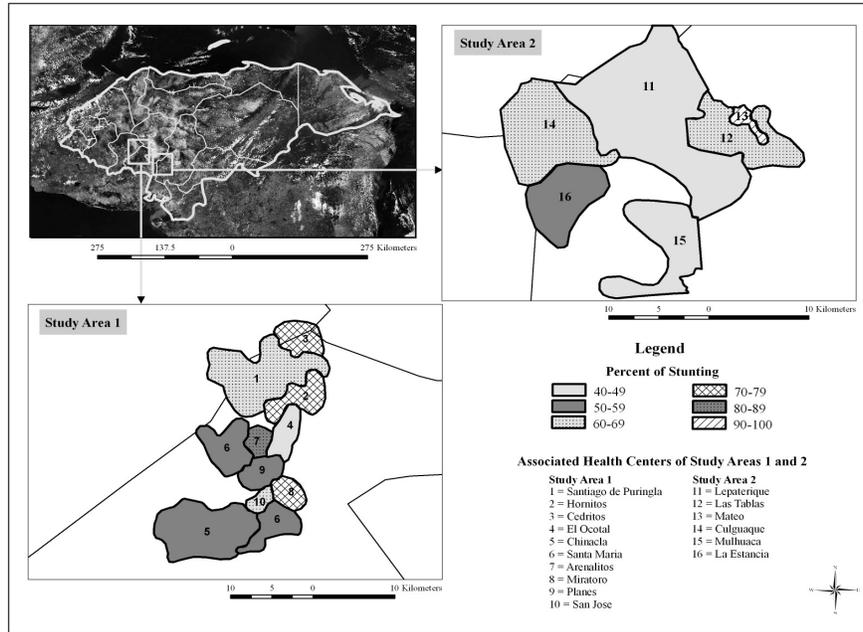
The location of the households was mapped based on

Figure 3. Percent of Stunted Honduran Children (6 to 60 months) Identified by Health Center
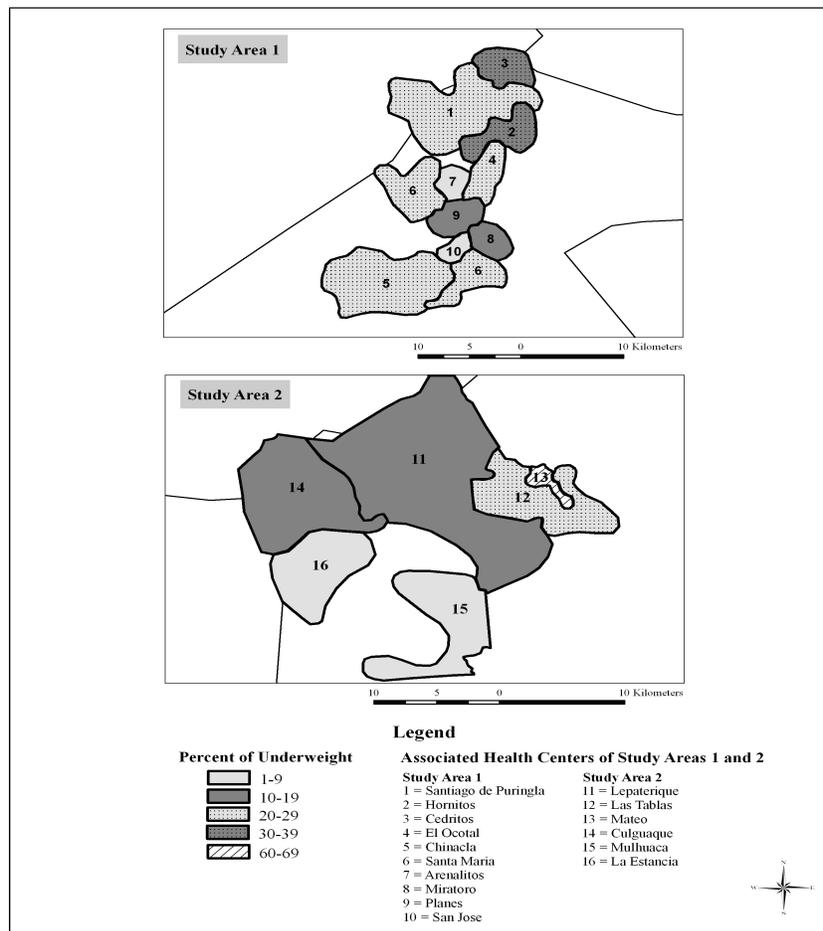

Figure 4. Percent of Underweight Honduran Children (6 to 60 months) Identified by Health Center

the documented latitude and longitude. All children are accounted for on the maps. Health center boundaries were estimated by including all clustered points. In Figure 3, the Honduras map, located on the top right corner, depicts the two study areas of interest. Study areas 1 and 2 were located in the south western part of Honduras. Study areas 1 and 2 were centered on 14° $16'$ $40''$ north latitude and 87° $54'$ $24''$ west longitude, and 14° $3'$ $32''$ north latitude and 87° $30'$ $10''$ west longitude, respectively. Figure 3 presents prevalence of stunting in areas 1 and 2 and the prevalence of underweight is displayed in Figure 4.

DISCUSSION

Mapping of the data reflects the distribution and high prevalence of undernutrition within the areas evaluated in rural Honduras with stunting at 56.8%, underweight at 20.8% and wasting at 1.6%. These results are considerably higher than recent reports for Honduras of 29% stunting, 8.1% underweight and 1% wasting (UNDP, 2013; WHO, 2012; UNICEF, 2012). The results reveal that the rural children evaluated within this study have higher growth deficiencies than that of the country as a whole (UNICEF, 2012). In respect to global comparisons, 26% are stunted, 16% are underweight and 8% are wasted (UNICEF, WHO and WB, 2012).

Nestel and colleagues evaluated growth status among Honduran children ages 12-71 months and determined that 38.5% of the children were stunted, 24.5% underweight and 1.5% wasted (Nestel et al., 1999). They identified the highest prevalence of stunting (60%) and underweight (38%) to be in the rural west (Nestel et al., 1999). A study conducted in Honduras by Tolson et al. (2010) reported that 57.2% of the children were stunted, 32.8% underweight and 3.5% wasted. Baseline information reported for a "Sprinkles" supplement study in Honduran children ages 6 to 60 months of age in 2006 and 2007 found the prevalence of stunting was 51.3%, underweight 15.4% and wasting 1.4% (Kemmer et al., 2012).

The National Epidemiological and Family Health Survey (ENESF) conducted in Honduras in 2001, reported that 29% of children were stunted, 16% were underweight and 1% were wasted (Ministry of Health, Honduras, and Honduran Family Planning Association, 2002; David et al., 2004). The Family Entitlement Program (PRAF-2002) study results in Honduras reported 53.6% stunting, 1.6% wasting and 30.2% underweight (David et al., 2004). Another study in Honduran children found the prevalence of stunting in children ages 12 to 36 months to be 35% and in children 36 to 60 months to be 38% (Albalak et al., 2000). Between 1987 and 2001 a downward trend in the levels of stunting in Honduran children ages 12 to 58 months from 43.8% in 1987 to 32.9% in 2001 and in wasting from

1.9% to 1.0% have been reported (David et al., 2004). It is essential to implement appropriate interventions early in life to have the greatest impact in preventing malnutrition (Shrimpton et al., 2001).

Within this study a number of socioeconomic factors were associated with stunting, underweight and wasting as shown in Table 2. Within Honduras, child's age, per capita household expenditures, household size, age difference with an older child, maternal height, birth intervals, education level of the household woman and household head have been previously identified as determinants of the child's nutritional status (David et al., 2004). Sparks (2011) found that children living in the lowest socioeconomic status (SES) group have a higher prevalence of stunting when compared to children living in the second poorest and highest SES and that breastfeeding duration can help overcome the SES gap resulting in improved nutritional status. Furthermore, SES has been identified to be clustered among geographical regions, meaning that individuals with lower (or higher) SES tend to live in geographical regions of other individuals that fall into the same socioeconomic class.

Factors previously identified to be attributed to stunting and underweight include SES factors such as demographics, low maternal education, poor nutrition knowledge, feeding practices for sick children, and household conditions such as lack of electricity and running water in the house (Phengxay et al., 2007; Singh et al., 2009; Som et al., 2007; Nestel et al., 1999). The significant relationship between socioeconomic status and nutritional deficiencies has been well documented (Uthman, 2008; Ergo et al., 2009).

As seen through the use of geographical mapping of the Honduran health centers, there are regions of greater nutritional disparity and regions of lesser concern. As identified within this study, the geographic areas within the health centers of Hornitos, Cedritos, Mateo, and Arenalitos are most need of nutritional intervention. These areas have a significantly higher prevalence of stunting, underweight, and/or wasting than the overall study population. Through the use of geographic targeting, there is the potential to substantially improve the severity but not necessarily the prevalence of stunting in Honduran (Morris et al., 2000). It has also been shown that regional characteristics as well as national policies and circumstances play a role in the causation or prevention of malnutrition (Dang et al., 2004).

Within this study, altitude was significantly associated with stunting and underweight. These results indicate that as altitude increases the prevalence of stunted and underweight children also increases. Previous studies have also correlated malnutrition, specifically stunting and underweight, with household altitude (Dang et al., 2004; Dang et al., 2008). Not only are those living in higher altitudes more prone to nutritional deficiencies that are related directly to elevation, but also tend to have a lower socioeconomic status and less access to varied

diets (Dang et al., 2004; Dang et al., 2008).

This is the first study reporting GPS mapping of the prevalence of stunting and underweight by health center in Honduras. Overall the prevalence of stunting is considered very high, underweight as high and wasting is low. SES indicators significantly associated with poor growth status have been identified. With the high prevalence of undernutrition in this area of Honduras, interventions need to be implemented to address this problem. Areas with the highest prevalence of undernutrition, mapped by health region, can be utilized by the Ministry of Healthy and other agencies to prioritize supplemental nutrition and education programs to areas at highest risk.

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