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Factors Associated with Undernutrition, Anemia, and Child Illness in 2014 Cambodia

Demographic Health Survey

By

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Master of Public Health

Hubert Department of Global Health

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Committee Chair

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Ellison Taylor

Bachelor of Science, Anthropology

Bachelor of Science, Microbiology: Biomedicine

Clemson University

2015

Thesis Committee Chair: Dr. Melissa F. Young, PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health in the Hubert Department of Global Health
2018

Abstract

Factors Associated with Undernutrition, Anemia, and Child Illness in 2014 Cambodia Demographic Health Survey

By Ellison Taylor

***Background**:* Strides have been made in reducing the incidence of undernutrition globally, but the burden of undernutrition still falls heavily on the shoulders of low and middle income countries, and especially on women and children. The effects of undernutrition can last into adulthood affecting cognitive and physical development, reducing productivity and increasing the risk for both infectious and chronic disease (UNICEF, 2015). Although Cambodia has made progress in reducing the prevalence of undernutrition, rates of stunting and anemia remain unacceptably high.

Objective: The main objective of this study was to understand the current consumption of animal-source foods (ASF) in Cambodia among children (6-59 months) and how that correlates to incidence of undernutrition (stunting, underweight, wasting), anemia and diarrhea.

Methods: Data from the nationally representative 2014 Cambodia Demographic Health Survey (CDHS) produced a sample of children 6-59 months with valid anthropometric measurements and completed questions on food consumption (n=1967). Multivariate linear and logistic regression were used to model the relationship between ASF consumption and height-for-age z-score (HAZ), weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), hemoglobin concentration, stunting, underweight, wasting, anemia, and diarrhea, adjusting for covariates.

Results: Consumption of any ASF was high (77.22%) across social and geographic variables, but it was not significantly associated with a lower risk of undernutrition. Consumption of ASF was associated with higher risk of anemia in children 25-59 months (OR=1.62; 95% CI 1.02, 2.58), contrary to previous literature. Wealth index was the strongest predictor for nutritional indices and greater wealth was especially associated with lower risk of stunting (OR=0.19; 95% CI 0.09, 0.40), underweight (OR=0.31; 95% CI 0.12, 0.79), anemia (OR=0.35; 95% CI 0.18, 0.67), and diarrhea (OR=0.48; 95% CI 0.25, 0.90) in children 6-24 months.

Conclusions: Nutrition-specific and nutrition-sensitive programs are required to comprehensively address the poverty-embedded problem of undernutrition in Cambodia. Additional research is needed to examine the quality of complementary foods upon their introduction and the quantity of ASF consumed to better understand the relationship between ASF consumption and undernutrition.

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Chapter I: Introduction

Background

Strides have been made in reducing the incidence of undernutrition globally, but the burden of undernutrition still falls heavily on the shoulders of low and middle income countries, and especially on women and children. The effects of undernutrition can last into adulthood affecting cognitive and physical development, reducing productivity and increasing the risk for both infectious and chronic disease (UNICEF, 2015). Although Cambodia has made progress in reducing the prevalence of undernutrition, rates of stunting (32.5%) and anemia (45%) remain unacceptably high (Emdin, 2017) (Valérie Greffeuille et al., 2016).

Research Gap

There is a need to understand the nuance of consumption of animal source foods among children and its association with malnutrition and foodborne illness in Cambodia. Studies have been conducted on similar populations using older iterations of Cambodia Demographic Health Survey (CDHS) data (Darapheak, Takano, Kizuki, Nakamura, & Seino, 2013). As undernutrition improves in Cambodia it is important to understand what factors have lessened malnutrition and what risk factors remain to be targeted to improve future interventions (Zanello, Srinivasan, & Shankar, 2016) (Valérie Greffeuille et al., 2016).

Purpose Statement and Specific Aims

The main objective of this study was to understand the current consumption of animal-source foods in Cambodia among children (6 - 59 months) and how that correlates to incidence of undernutrition (stunting, underweight, wasting), anemia, and diarrhea as of the 2014 CDHS survey.

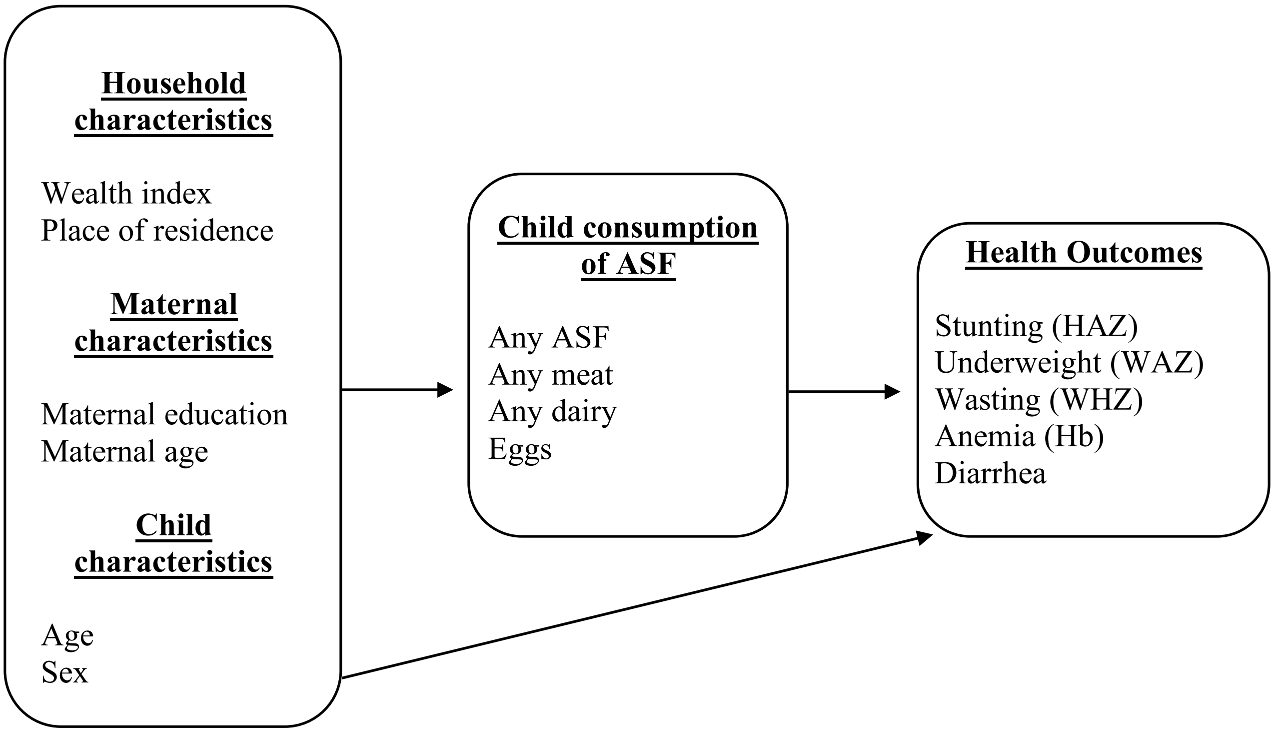


Figure 1. Conceptual framework

The aims of this study were to:

- Characterize child and infant consumption of ASF
- Examine associations between any ASF consumption and stunting, underweight, wasting, anemia, and diarrhea
- Examine associations between household and individual sociodemographic variables and stunting, underweight, wasting, anemia, and diarrhea

Chapter 2: Literature Review

Malnutrition remains a serious problem globally, especially in low and middle income countries (LMIC). Worldwide, more than 300 million children younger than 5 are estimated to be chronically undernourished and nutritional insufficiency accounted for 3.4% of the total global burden of disease in 2010 (Ikeda, Irie, & Shibuya, 2013) (Murray et al., 2012). It is estimated that aggregate undernutrition is the cause of 3.1 million child deaths annually, which accounts for 45% of all child deaths in 2011 (Black et al., 2013). Malnutrition can refer to undernutrition and overweight and obesity. Indicators of undernutrition include stunting (low height for age), wasting (low weight for height), underweight (low weight for age) and micronutrient deficiencies (a lack of essential vitamins or minerals). Stunting, underweight, and wasting are determined by a z-score (standard deviation) that is more than 2 standard deviations below the age-sex median or mean for a well-nourished reference population (Mercedes de Onis, 1997). Stunting is an indicator of chronic malnutrition, wasting is an indicator of acute malnutrition, and underweight is an indicator of both (Darapheak et al., 2013). UNICEF reports that in 2013 there were 161 million children chronically undernourished (stunted) and 51 million children acutely undernourished (wasted) (UNICEF, 2015). While the prevalence of stunting in children under-five has decreased globally, it still remains high, especially in South Asia and Africa (Black et al., 2013).

Women of reproductive age and children are the most at-risk populations for malnutrition, including undernutrition, micronutrient deficiencies, overweight, and obesity (V. Greffeuille et al., 2016). Poor nutrition in childhood—especially in the first 1000 days of life, the critical window between the start of the woman's pregnancy and the child's second birthday—has lasting consequences (UNICEF, 2015). A malnourished child has a weaker immune system and is at higher risk of contracting and even dying of common infectious diseases like diarrhea and pneumonia (UNICEF, 2015). Stunting and underweight are associated with risk of infection and have long-term effects; wasting poses a greater risk of dying from diseases like diarrhea or pneumonia compared to healthy children (Darapheak et al., 2013). Conversely, diarrhea is associated with an increased risk of child malnutrition, illustrating the synergy between these two conditions (UNICEF, 2015) (Darapheak et al., 2013). Upon reaching adulthood, children who were undernourished are more at risk of chronic disease, completing fewer years of school, and lower workforce productivity (UNICEF, 2015). The impacts of undernutrition not only last throughout life, but they transcend generations. Short maternal stature is associated with low birthweight, child stunting, delivery complications and an increased risk of child mortality, even after adjusting for socioeconomic status (SES) (Martorell & Zongrone, 2012). Additionally, low maternal weight is associated with maternal mortality, preterm birth, and neonates that are small for their gestational age (V. Greffeuille et al., 2016). Overweight status in both women and men is associated with an increased risk of non-communicable diseases, and for women, adverse pregnancy outcomes (V. Greffeuille et al., 2016).

UNICEF estimates that poor nutrition reduces a nation's economic advancement by 8% (UNICEF, 2015). Studies have found that Cambodia is losing millions of dollars as a consequence of poor nutrition. One study found that indicators of malnutrition cost the national Cambodian economy 266 million dollars (1.7% of GDP) (Moench-Pfanner et al., 2016) and another found it to be more than $400 million annually (Bagriansky, Champa, Pak, Whitney, & Laillou, 2013). 57% of these losses derive from indicators measured in children while the remaining 43% are related to indicators of maternal behavior and adult nutrition (Bagriansky et al., 2013).

Food insecurity and undernutrition are especially pronounced in countries recovering from recent conflicts and civil unrest (Hong & Mishra, 2006). With its recent history of civil war and genocide, Cambodia has made massive economic strides but is still recovering. There was rapid socioeconomic development in Cambodia attributed to its transition towards an open market economy in 1991 and now Cambodia is on the brink of becoming a middle income country (Ikeda et al., 2013). Existing food systems are changing with urbanization, increasing income and free markets in many LMICs, which leads to a greater diversity and availability of food (Workicho et al., 2016). The access to this food, however, is not universal. While its economy has grown significantly and progress has been made towards public health goals, Cambodia's wealth inequality threatens progress (Ecker & Diao, 2011). Public health improvements, especially relating to malnutrition indicators, are thought to benefit the rich far more than the poor (Valérie Greffeuille et al., 2016) (Hong & Mishra, 2006). The pathway from economic growth to food security can be disrupted by wealth inequalities and economic gains concentrating among the wealthy, as well as inequitable food allocation at the household level (Ecker & Diao, 2011).

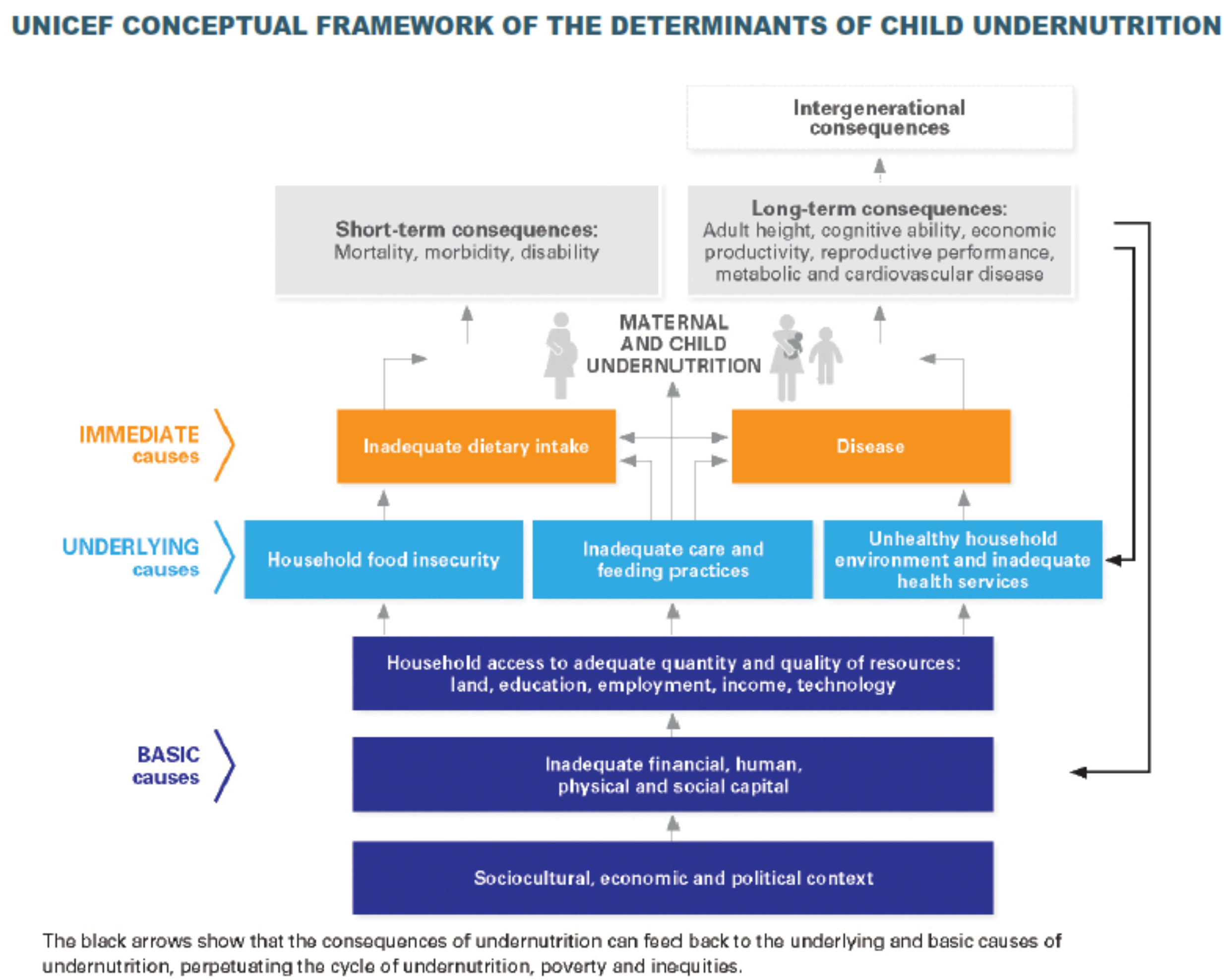


Figure 2. Conceptual framework of malnutrition, adapted from UNICEF 1990 (UNICEF, 2015)

Figure 2 shows how the determinants of child undernutrition extend beyond a lack of caloric intake. The underlying and basic causes of undernutrition, like poverty and civil strife, influence the proximal causes of undernutrition. Cambodia is one of the poorest countries and has some of the highest prevalence rates of malnutrition and undernourishment in South and Southeast Asia (Ecker & Diao, 2011). Nearly one third of Cambodia lives below the poverty line, despite economic growth (Ikeda et al., 2013). Given this, there has been modest progress on the front of malnutrition, though more is needed. A nationally representative survey looked at factors that could have contributed to the reduction in stunting that was observed in Cambodian children between 2000 and 2010. Stunting prevalence decreased from 49.3% in 2000 to 39.0% in 2010 (Ikeda et al., 2013). Researchers attributed the reduction to socioeconomic development and public health improvements including household wealth, sanitation, parental education, birth spacing and maternal tobacco use (Ikeda et al., 2013). Child stunting was associated with child's sex and age, type of birth, maternal height, maternal body mass index, previous birth intervals, number of household members, household wealth index score, access to improved sanitation facilities, presence of diarrhea, parents' education, maternal tobacco use, and mother's birth during the Khmer Rouge famine (Ikeda et al., 2013).

In 2014, indicators of undernutrition in children continue to slowly improve as shown in Figure 3. The 2014 Demographic Health Survey (DHS) indicates that 32% of children under five are stunted (chronic malnutrition) and 10% of children under five are wasted (acute malnutrition) (National Institute of Statistics, 2015a).

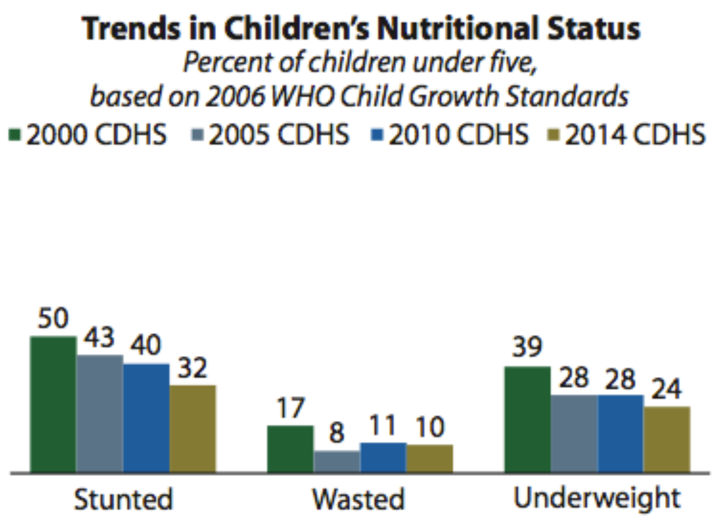


Figure 3. (National Institute of Statistics, 2015a)

These improvements in child nutrition are not equitably distributed, however. Using information from the 2000 Cambodia Demographic Health Survey found that children in the poorest 20% of households were twice as likely to be stunted, an indicator of chronic malnutrition, as children in the richest 20% of households, adjusting for age, sex, birth order, duration of breastfeeding age of mother at birth, BMI, education, household access to safe drinking water, hygienic toilet facility, residence, and geographic region (Hong & Mishra, 2006).

The issue of nutrition is experiencing a shift as countries begin to simultaneously suffer undernutrition and overweight and obesity. One study looking at Cambodian women, discovered that, for the first time in 2014, there was a higher percentage of overweight prevalence than underweight among women in Cambodia (V. Greffeuille et al., 2016). Figure 4 illustrates this finding where the DHS estimates that 18% of women 15-49 are overweight or obese and about 14% of Cambodian women are thin (National Institute of Statistics, 2015a). Age, wealth index, number of children, and year of survey are positively correlated with overweight status; Overweight status is negatively correlated with anemia and increase in education level (V. Greffeuille et al., 2016). Conversely, age, wealth index, maternal education, number of children, year of survey, and anemia all contributed to underweight status. Overall, younger women are more at risk of being underweight than older women.

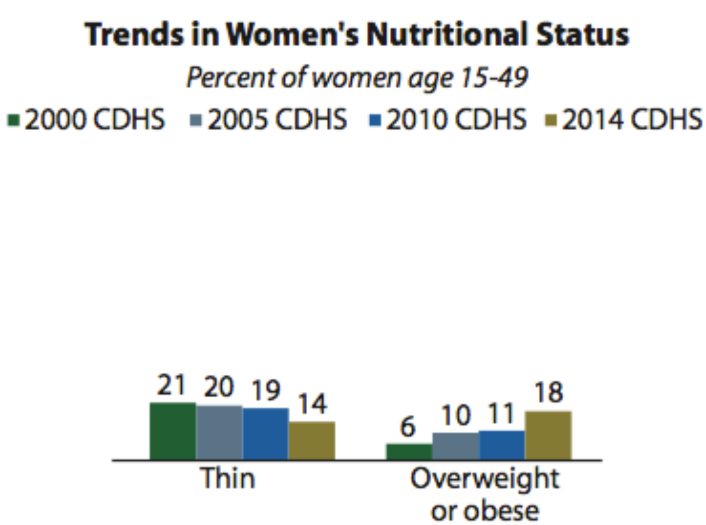


Figure 4. (National Institute of Statistics, 2015a)

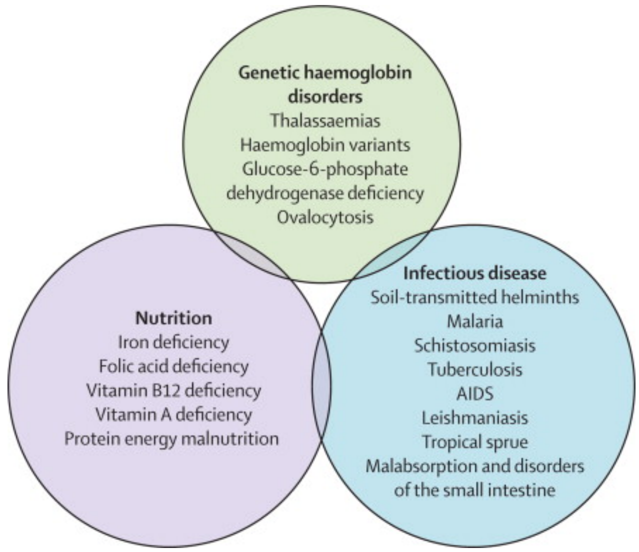


Figure 5. Causes of anemia in LMICs (Balarajan, Ramakrishnan, Özaltin, Shankar, & Subramanian, 2011)

Another common public health problem, across the world and especially in Africa and Asia, is anemia. Anemia refers to low hemoglobin concentration, red cell count, or packed cell volume and the resulting inability to meet the oxygen demand of tissues (Balarajan et al., 2011). Anemia can cause several adverse outcomes including fatigue, reduced productivity, and poor cognitive and motor development in children (V. Greffeuille et al., 2016) (Balarajan et al., 2011). In Cambodia, anemia remains high with 45% of women 15-49 and 56% of children 6-59 months having any anemia, according to the 2014 DHS (National Institute of Statistics, 2015a). Figure 5 shows the causes of anemia extend beyond nutritional factors and can include infectious diseases and hemoglobin disorders. This is especially true for Cambodia where over 40% of anemia is not associated with nutritional factors (Wieringa et al., 2016). Analysis of the CDHS 2014 micronutrient survey found that zinc deficiency, hookworm infection and hemoglinopathy were significantly associated with anemia in children (Wieringa et al., 2016). Iron deficiency anemia was seen to be more prevalent in children <2 years old (~10%) but was not prevalent in children and women (<5%) (Wieringa et al., 2016). In the CDHS 2014, anemia was seen at high rates even among women in wealthier groups, indicating that non-nutritional factors might be contributing to low hemoglobin levels (V. Greffeuille et al., 2016). For example, it is estimated that in Cambodia about half of the population is affected by a hemoglobin disorder (V. Greffeuille et al., 2016). However, the positive association of anemia with underweight women, and the negative association of anemia with overweight women, suggests that there remain some nutritional determinants of anemia in underweight women.

An often-overlooked micronutrient deficiency is thiamine deficiency. Thiamine is critical in cellular energy generation and modulates neuronal and neuromuscular transmission (Whitfield et al., 2017). Deficiency in thiamine can also lead to beriberi, which can be fatal (Whitfield et al., 2017). A nationally representative sample of Cambodian women 15-49 years and their children, 6-69 months, show that 27% of and 15% of children were thiamine deficient (using the most conservative thiamine cutoff of <120 nmol/L). This was especially true for infants 6-12 months, who were 38% deficient using the most conservative cutoff (Whitfield et al., 2017).

To assess diet quality in LMICs, dietary diversity is commonly used as a proxy. Dietary diversity is defined as the number of unique foods or food groups consumed over a defined period and is often used as a proxy for measuring nutrient adequacy and adequate intake of micronutrients (Workicho et al., 2016). A higher Dietary Diversity Score is associated with an increased nutrient intake and better nutritional status and household per capita energy consumption (Workicho et al., 2016). A survey administered in four rural districts of Prey Veng, Cambodia, was conducted to assess for a potential correlation between household food insecurity and Household Dietary Diversity Score and maternal and child anthropometric status, including child stunting and wasting, maternal thinness, and maternal and child anemia (McDonald et al., 2015). The study observed a high prevalence of household food insecurity and low dietary diversity. Despite common child undernutrition, neither food insecurity nor dietary diversity status were correlated with child stunting, wasting, or anemia. However, household food insecurity increased the risk of maternal thinness and maternal anemia in a dose-response manner, indicating that there may inequitable distribution of nutritional resources within the household. A randomized controlled trial in two provinces of northern Cambodia looked at how the Food and Agriculture Organization's educational intervention and food security project affected health outcomes (Reinbott et al., 2016). The researchers found that wealth, child's age, and maternal education were determinants of a child's dietary diversity (Reinbott et al., 2016).

Animal-source food (ASF) consumption is linked to dietary diversity and quality and it is commonly used to assess dietary intake and quality in low and middle income countries as well (Workicho et al., 2016). ASF consumption provides protein and essential micronutrients like zinc, iron, calcium, Vitamin A, Vitamin B-12, and riboflavin (Murphy & Allen, 2003). Inadequate intake of the aforementioned micronutrients can have negative health outcomes like anemia, poor physical growth, impaired cognition, blindness, and morbidity and mortality (Murphy & Allen, 2003). A study in Guatemala, Zambia, Pakistan and the Congo found that meat consumption was associated with a reduced risk of stunting (OR=0.64; 95% CI, 0.46 to 0.90). Another study found that found that a diverse diet was a protective factor of stunting but not underweight status among Cambodian children aged 12 to 59 months (Darapheak et al., 2013). Consumption of ASF appeared to be independently associated with a decreased risk of stunting and underweight status (Darapheak et al., 2013). However, a higher risk of diarrhea was identified among children consuming milk products (Darapheak et al., 2013). Therefore, it is posited that ASF consumption can confer both protection and risk.

Infants are especially vulnerable to malnutrition during the transition from exclusive breastfeeding to complementary feeding (CF), breastfeeding supplemented by solid foods (Mamiro et al., 2005). The European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) Committee on Nutrition recommends complementary feeding be introduced between 4-6 months and all infants should receive iron-rich complementary foods including meat products or iron fortified foods (Fewtrell et al., 2017). Providing high-quality complementary foods during this critical period can have a profound impact. A study in Bangladesh on 0-23 month-olds found that exclusive breastfeeding <6 months was associated with higher WHZ, appropriate CF was associated with higher HAZ, and higher dietary diversity index (DDI) was associated with both higher HAZ and WAZ (Zongrone, Winskell, & Menon, 2012). Adequate nutrition during these critical months can improve indicators of both chronic and acute malnutrition.

Overall, malnutrition in Cambodia is improving but only modestly. Prevalence of malnutrition remains high for the region, therefore better understanding predictors and determinants and how to mitigate them is essential.

Chapter 3: Project Context

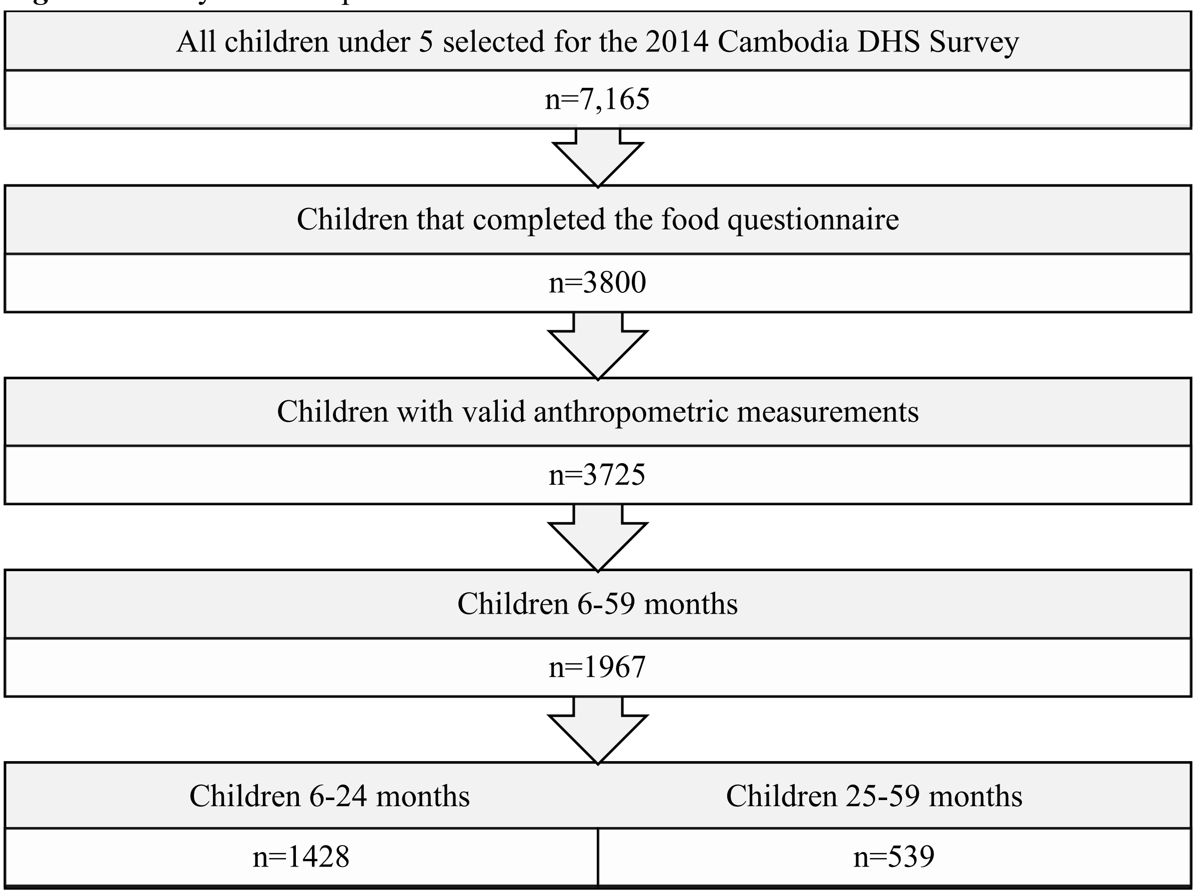
METHODOLOGY

Demographic Health Survey Sample

2014 Cambodia Demographic Health Survey (CDHS) is a nationally representative survey of 15,825 households. It was conducted by the Directorate General for Health of the Ministry of Health and the National Institute of Statistics of the Ministry of Planning. Two-stage stratification sampling was used to select the households. First the country was divided into 19 domains made up of 14 individual provinces and 5 groups of provinces, using enumeration areas derived from the 2008 Cambodia General Population Census. These domains were then stratified by residence (urban or rural) into 38 sampling strata. Samples were then selected independently in each stratum to yield 611 clusters (188 urban, 423 rural). A listing of all households in each cluster was obtained and then houses were selected for sampling (24 in urban clusters, 28 in rural clusters). Oversampled areas were corrected for during analysis using sample weights.

All women aged 15-49 years in the household were interviewed. Respondents were also asked about the health status of the children in the household, including the nutritional intake of youngest child. A subsample of 1/3 of households was selected to interview men aged 15-49 years. In the households where men were not interviewed (2/3 of households) children <5 years of age and women aged 15-49 years were eligible for anemia testing and anthropometric measurements. Height and weight were measured suing SECA scales and measuring boards. From this data three nutritional indices were produced: stunting (height-for-age z-score), underweight (weight-for-age z-score) and wasting (weight-for-height z-score). Stunting, underweight, and wasting were defined as a z-score <-2SD from the WHO reference population. Hemoglobin levels were tested using the HemoCue System. Anemia was defined as blood hemoglobin concentration <11 g/dL adjusted for elevation. A wealth index was created using principal components analysis and households were ranked into quintiles (National Institute of Statistics, 2015b).

Figure 6. Analysis of sample derivation



Analytic Strategy

Figure 6 details how the final sample was derived. Observations were only included if they completed the food questionnaire (therefore only the youngest child in the household was included), they had valid anthropometric measurements, and they were between 6 and 59 months at the time of the survey. Descriptive analysis was done using cross-tabulation. Initially for explanatory modeling, bivariate relationships were examined between both ASF consumption and nutritional indicators against several household and individual characteristics. Multiple logistic regression models were created for stunting, underweight, anemia, and diarrhea to identify influential variables for two age categories: 6-24 months and 25-59 months. Multiple linear regression models were created for height-for-age z-score (HAZ), weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), and hemoglobin concentration (g/dL) to identify influential variables for the same age categories. Models were selected by determining significant variables through bivariate analyses. The determined alpha-level for all regression analyses was 0.05. Complex sample design was adjusted for throughout analysis by including sampling weights.

RESULTS

Study Participants

The characteristics of 1967 children aged 6-59 months that were included in the sample are shown in Table 1. The majority of the population was rural, 85.54%. The population was nearly evenly distributed between the wealth index quintiles, with a slightly higher concentration in the poorest category. The study sample was 49.28% female with a mean age of 31.79 months. The mean age of the child's mother was 28.89 and the mean duration of education was 5.02 years.

Table 1. Characteristics of 1967 children aged 6-59 months, Cambodia 2014

Characteristic		% or mean (SD)
Household Characteristics		
Residence (Rural)		86.53%
Wealth Index		
	Poorest	27.31%
	Poorer	19.49%
	Middle	19.22%
	Richer	15.96%
	Richest	18.01%
Maternal Characteristics		
Maternal age (years)		27.64 (5.64)
Maternal education (years)		5.13 (3.74)
Educational Attainment of Mother		
	No Education	13.23%
	Incomplete Primary	43.25%
	Complete Primary	11.89%
	Incomplete Secondary	24.92%
	Complete Secondary	3.35%
	Higher	3.36%
Child Characteristics		
Child age (months)		22.69 (14.76)
Child age categories (months)		
	6-12	23.48%
	12-23	48.38%
	24-35	6.88%
	36-47	10.78%
	48-59	10.49%
Child sex (female)		48.05%
Child Nutrition		
Child height-for-age- z-score (HAZ)		-1.35 (1.31)
Child stunting		29.66%
Child weight-for-age z-score (WAZ)		-1.20 (1.09)
Child underweight		21.61%
Child weight-for-height z-score (WHZ)		-0.66 (1.16)
Child wasting		9.95%
Child hemoglobin concentration adjusted for altitude (g/dL)		10.33(1.34)
Child anemia (Hb<11.0)		66.74%
Child diarrhea within last two weeks		16.57%
Child consumption of any ASF		77.22%
Child consumption of any meat		71.28%
Child consumption of dairy		19.22%
Child consumption of eggs		34.69%
Children currently breastfeeding		73.89%

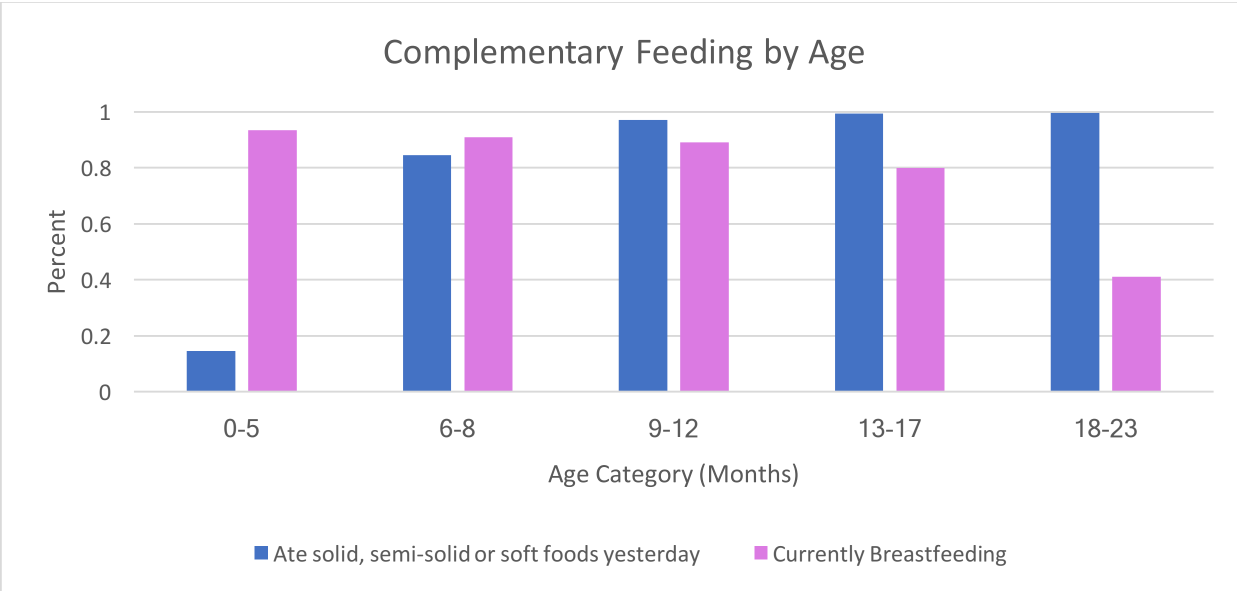


Figure 7. Percent of children currently breastfeeding and having eaten solid, semi-solid or soft foods in the last 24 hours among 1967 children aged 6-59 months, Cambodia 2014

Complementary Feeding

Table 1 shows that 73.89% of children were currently breastfeeding at the time of the survey. Figure 7 shows complementary feeding by age group. Complementary feeding was low between 0-5 months (14.64%) but by 6-8 months complementary feeding was 84.51%. The majority of children began complementary feeding in accordance with WHO recommendations that state that all infants begin complementary feeding at 6 months (WHO, 2002). However, 14.64% of children were introduced to complementary foods too early (0-5 months) and 15.49% were introduced to complementary foods too late (9-12 months), indicating that 30.13% of children were not in compliance with WHO recommendations.

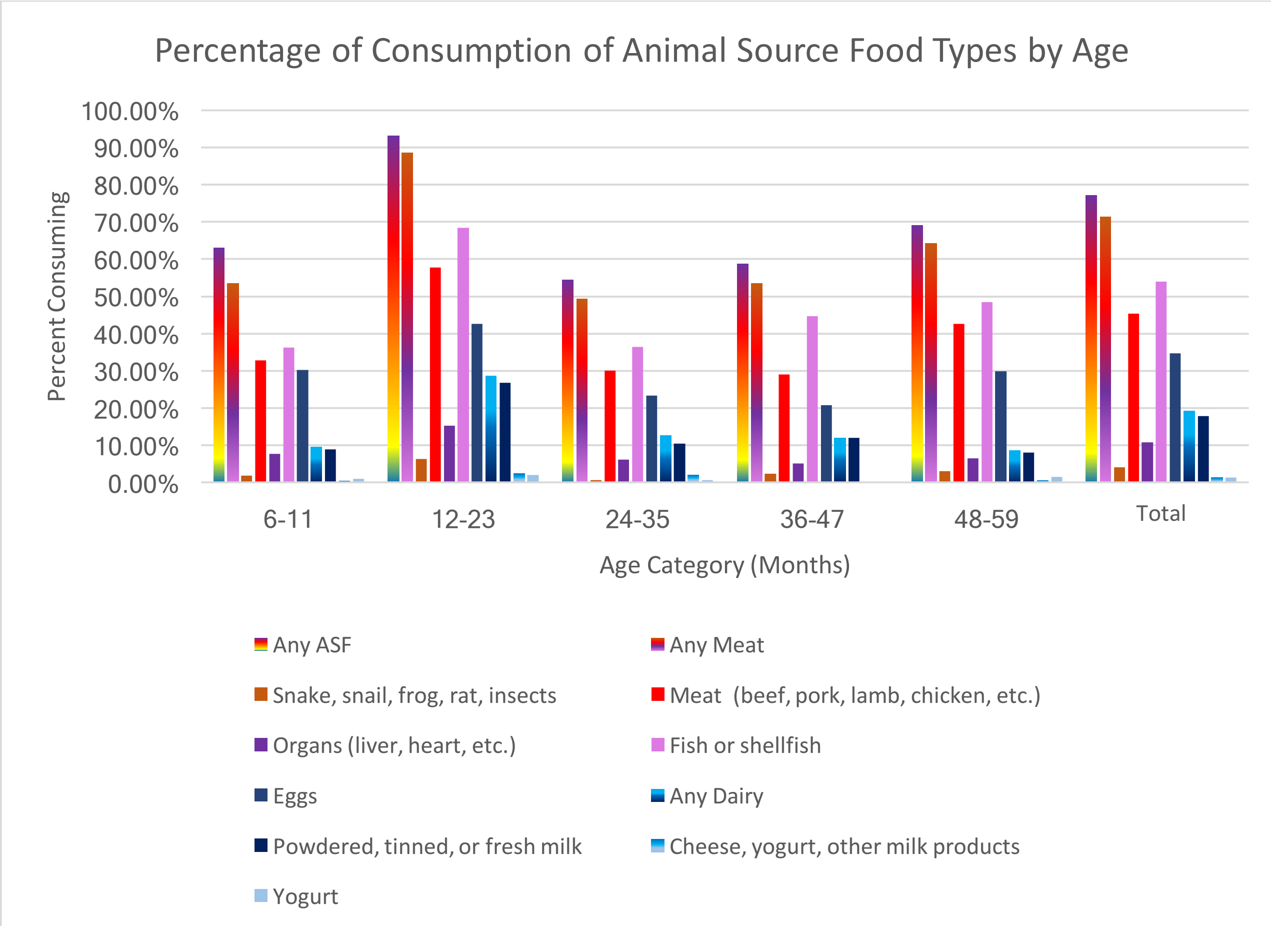


Figure 8. Percentage consumption of animal-source foods by age category among 1967 children aged 6-59 months, Cambodia 2014

Animal-source foods

Table 1 shows that the consumption of any ASF, any meat, any dairy, and eggs was 77.22%, 71.28%, 19.22%, and 34.69%, respectively, for all sampled children. Figure 8 shows the percentage of children 6-59 months that consumed noted animal-source foods in the 24 hours preceding the survey. Eggs, meat, and shellfish feature prominently in all age categories. Snake, snail, frog, rat, insects and cheese, yogurt and other milk products were consumed at near negligible amounts in all age categories. Consumption of any ASF peaked at 12-23 months with 91.77% of children consuming any ASF in the day prior to the survey. The biggest contributor to consumption of any ASF was fish and shellfish, followed by meat (beef, pork, lamb, chicken, etc.).

Table 2 shows that consumption of any ASF increased modestly by wealth index and it increased dramatically by wealth index for dairy. Consumption of ASF was slightly higher among children born to mothers with secondary or higher education, urban children and male children. Consumption of any meat was high and did increase with wealth quintile (74.21% for richest quintile), education of the mother (78.0% for mothers with higher education), and for urban (79.85%) and male (72.10%) children. Consumption of any dairy also increased with wealth quintile (34.02% for richest quintile), education of the mother (41.33% for mothers with complete secondary education), and for urban (29.33%) children. Consumption of eggs varied across all categories. The poorer and richest wealth quintiles consumed the most eggs, 41.17% and 41.51% respectively. Mothers with higher education had children that consumed the most eggs with 43.02%. Urban children consumed more eggs (42.07%) but egg consumption did not vary by sex.

Table 2. Association between consumption of animal source foods and socioeconomic and geographic variables for 3979 children aged 6-59 months, Cambodia 2014

Socioeconomic/Geographic Variables	n	% Consumed in Last 24 Hours Any ASF	Any Meat	Any Dairy	Eggs
Wealth Index					
Poorest	547	74.30%	69.73%	8.19%	27.88%
Poorer	390	77.15%	68.18%	15.37%	41.17%
Middle	385	78.75%	74.25%	18.12%	29.39%
Richer	319	77.06%	70.85%	27.42%	37.10%
Richest	360	80.21%	74.21%	34.02%	41.51%
Educational Attainment of Mother					
No Education	265	70.49%	65.95%	9.47%	25.76%
Incomplete Primary	865	78.13%	73.44%	13.85%	33.87%
Complete Primary	238	73.65%	60.24%	31.83%	31.30%
Incomplete Secondary	499	77.13%	73.29%	23.05%	40.51%
Complete Secondary	67	94.86%	81.88%	41.33%	40.89%
Higher	67	87.60%	78.06%	31.66%	43.02%
Type of Residence					
Urban	270	84.45%	79.85%	29.33%	42.07%
Rural	1731	76.09%	69.95%	17.65%	33.54%
Sex of Child					
Male	1039	78.04%	72.10%	19.30%	34.62%
Female	961	76.33%	70.40%	19.13%	34.76%

Prevalence of health indicators

Table 1 shows that the overall prevalence of stunting was 29.66 % with a mean HAZ of -1.35. Table 3 shows that prevalence of stunting decreases drastically with wealth quintile, 40.17% for the poorest quintile and 15.77% for the richest. Stunting also decreased with higher educational attainment for the mother, 35.13% for children to mothers with no education and 19.61% for children with mothers with higher education (Table 3). Stunting was higher in rural areas (31.25%) and was slightly higher for males (Table 3).

The overall prevalence of underweight was 21.61% with a mean WAZ of -1.20 (Table 1). The prevalence of underweight decreased by wealth index from poorest to richest, 29.41% to

11.31% (Table 3). Prevalence of underweight also decreased by the educational attainment of the mother from no education to higher education, 24.08% to 4.38% (Table 3). Prevalence of underweight was higher for rural children, 23.21%, and did not vary much by sex (Table 3).

The overall prevalence of wasting was 9.95% with a mean WHZ of -0.66 (Table 1). Prevalence of wasting decreased slightly as wealth increased, 11.97% for the poorest and 7.89% for the richest (Table 3). Wasting also decreased with a mother's education attainment, 14.43% for mothers with no education and 3.08% for mothers with higher education (Table 3). Prevalence of wasting was slightly higher in rural areas and did not vary by sex of the child.

The overall prevalence of any anemia was 66.74% with a mean hemoglobin concentration of 10.33 g/dL (Table 1). Prevalence of anemia decreases as wealth increases, 64.69% for the poorest wealth quintile and 43.92% for the richest (Table 3). Prevalence of anemia decreases as maternal education increases and it is significantly higher for rural children, 69.03% (Table 3). There was no substantial different in anemia by sex.

As seen in Table 1, 16.57% of the sampled population had diarrhea within the last two weeks. Diarrhea decreases slightly as wealth increases, 17.18% for the poorest and 10.70% for the richest (Table 3). Diarrhea varied greatly by educational attainment of the mother and was slightly higher for rural children, 17.04 % (Table 3). There was no difference in anemia by sex.

Risk factors for stunting, underweight and wasting

Multivariate linear regression models were run for HAZ, WAZ, WHZ, and hemoglobin concentration, testing consumption of ASF as an exposure, and controlling for child age, child sex, residence, wealth, and maternal education. The results from this model can be seen in Table 4. Multivariate logistic regression models were run for stunting, underweight, wasting, anemia, and diarrhea, testing consumption of ASF as an exposure, and controlling for the same potential confounders as the multivariate linear regression models. The odds ratios obtained from these models are shown in Table 5. Both the linear and logistic regression models were run both for 6-24 months and 25-59 months as their consumption of ASF differed. Consumption of ASF was not significantly associated with HAZ, WAZ, WHZ, stunting, underweight, or wasting for either age category. Child's age in months was significantly associated with lower HAZ and WAZ and stunting and underweight for 6-24 months. Being female was significantly associated with lower WAZ scores and increased risk of underweight for 25-59 months. Being a female was significantly associated with a decreased risk of stunting and underweight for 6-24 months. Greater wealth was significantly associated with higher HAZ and WAZ for both age categories and significantly associated with decreased risk for stunting and underweight for 6-24 months. Maternal education in years was significantly associated with higher HAZ for 25-59 months. Urban residence and maternal age were not significantly associated with HAZ, WAZ, WHZ, stunting, underweight, or wasting.

Risk factors for anemia

Multivariate linear regression models run for hemoglobin concentration, testing consumption of ASF as an exposure, and controlling for child age, child sex, residence, wealth, and maternal education, can be seen in Table 4. Multivariate logistic regression models were run for anemia, testing consumption of ASF as an exposure, and controlling for the same potential confounders as the multivariate linear regression models, can be seen in Table 5. Consumption of any ASF was significantly associated with lower hemoglobin concentration and higher risk of anemia for ages 25-59 months. Child age was significantly associated with slightly higher hemoglobin concentrations and slightly less risk of anemia for ages 6-24 months. Being female was significantly associated with higher hemoglobin concentration for ages 6-24 months. Living in an urban area was significantly associated with higher hemoglobin concentration and a much lower risk of anemia for 25-59 months. Greater wealth was significantly associated with a higher hemoglobin concentration and a lower risk of anemia for 6-24 months. Maternal education and maternal age were not significantly associated with either hemoglobin concentration or risk of anemia.

Table 3. Prevalence of stunting, underweight, wasting and diarrhea by socioeconomic and geographic characteristics for 1967

Socioeconomic/Geographic	Stunting		Underweight		Wasting		Anemia [a]		Diarrhea [b]	
Variables	n	%	n	%	n	%	n	%	n	%
Wealth Index										
Poorest	214	40.17%	157	29.41%	64	11.97%	389	72.68%	114	20.85%
Poorer	122	32.05%	96	25.00%	50	13.14%	275	72.47%	64	16.29%
Middle	118	30.84%	79	20.83%	31	8.19%	248	64.72%	63	16.31%
Richer	73	23.09%	53	16.82%	23	7.15%	202	66.23%	52	16.15%
Richest	55	15.77%	40	11.31%	28	7.89%	180	53.62%	40	11.03%
Educational Attainment of Mother										
No Education	93	35.13%	63	24.08%	39	14.73%	177	67.47%	59	22.14%
Incomplete Primary	279	33.00%	204	24.21%	76	9.04%	564	67.20%	131	15.19%
Complete Primary	67	28.39%	40	16.89%	19	8.19%	174	75.39%	49	20.45%
Incomeplete Secondary	115	23.55%	101	20.73%	54	10.96%	307	63.67%	73	14.57%
Complete Secondary	17	24.70%	13	18.93%	6	8.13%	37	57.18%	16	24.06%
Higher	13	19.61%	3	4.38%	2	3.08%	34	58.69%	4	6.02%
Type of Residence										
Urban	52	19.47%	30	11.41%	20	7.53%	127	51.21%	37	13.52%
Rural	531	31.25%	394	23.21%	176	10.33%	1166	69.03%	295	17.04%
Sex of Child										
Male	327	32.03%	228	22.31%	110	10.74%	676	67.01%	168	16.13%
Female	256	27.09%	197	20.86%	86	9.11%	617	66.46%	164	17.04%

[a] Anemia is defined as any hemoglobin measurement <11.0 g/dl)

[b] Diarrhea is defined as reported diarrhea in the last two weeks.

Risk factors for diarrhea

Multivariate logistic regression models were run for diarrhea, testing consumption of ASF as an exposure, and controlling for the same potential confounders as the multivariate linear regression models, and odds ratios can be seen in Table 4. Consumption of ASF was not significantly associated diarrhea. Maternal age was significantly associated with a lower risk of diarrhea for ages 6-24 months. Wealth was significantly associated with a lower risk of diarrhea for both 6-24 months and 25-59 months, OR=0.48 and OR=0.21, respectively. Child age, child sex, residence, and maternal education were not significantly associated with a risk of diarrhea for either of the age categories.

Table 4. Associations between ASF consumption and sociodemographic factors and height-for-age z-score (HAZ), weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), and hemoglobin using linear regression models by age group[a]

Linear Regression Model [a]	**Height-for-age z-score** β (SE)		**Weight-for-age z-score** β (SE)		**Weight-for-height z-score** β (SE)		**Hemoglobin (g/dl)** β (SE)	
	6-24 mo	*25-59 mo*	*6-24 mo*	*25-59 mo*	*6-24 mo*	*25-59 mo*	*6-24 mo*	*25-59 mo*
Any ASF	-0.041 (0.109)	0.061 (0.117)	-0.124 (0.117)	-0.001 (0.112)	-0.167 (0.147)	-0.051 (0.125)	0.140 (0.131)	**-0.270 (0.118)**
Child age (months)	**-0.061 (0.008)**	-0.004 (0.006)	**-0.033 (0.007)**	-0.010 (0.006)	-0.015 (0.009)	-0.007 (0.005)	**0.026 (0.009)**	0.009 (0.006)
Female child	0.146 (0.081)	-0.155 (0.110)	0.140 (0.076)	**-0.214 (0.102)**	0.119 (0.083)	-0.101 (0.108)	**0.232 (0.085)**	-0.013 (0.117)
Urban residence	0.012 (0.108)	0.211 (0.194)	0.025 (0.116)	0.215 (0.190)	0.050 (0.138)	0.118 (0.187)	0.056 (0.137)	**0.412 (0.198)**
Maternal age	-0.002 (0.008)	0.004 (0.011)	0.006 (0.005)	0.003 (0.011)	0.010 (0.007)	0.001 (0.011)	0.012 (0.007)	0.002 (0.013)
Poorest Wealth Quintile	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Poorer	0.060 (0.126)	0.060 (0.162)	0.128 (0.106)	0.188 (0.157)	0.123 (0.125)	0.207 (0.167)	0.182 (0.128)	0.012 (0.162)
Middle	0.225 (0.126)	0.233 (0.183)	**0.257 (0.105)**	0.193 (0.166)	0.181 (0.118)	0.087 (0.152)	**0.487 (0.137)**	0.185 (0.208)
Richer	**0.461 (0.143)**	0.214 (0.193)	**0.371 (0.121)**	0.234 (0.169)	0.171 (0.132)	0.145 (0.194)	**0.490 (0.178)**	-0.021 (0.208)
Richest	**0.667 (0.150)**	**0.546 (0.227)**	**0.596 (0.152)**	**0.443 (0.201)**	0.320 (0.181)	0.158 (0.213)	**0.714 (0.179)**	0.324 (0.276)
Maternal education (yrs)	0.002 (0.013)	**0.044 (0.017)**	0.015 (0.012)	0.031 (0.018)	0.020 (0.013)	0.006 (0.020)	0.008 (0.014)	-0.012 (0.019)

[a] total sample for models: n=1967

* Values that are statistically significant at alpha level of 0.05 bolded

Table 5. Associations between ASF consumption and sociodemographic factors and stunting (HAZ<-2), underweight (WAZ<-2), wasting (WHZ<-2), anemia (Hb<11g/dl), and diarrhea using logistic regression models by age group[a]

Logistic Regression Model [a]	Stunting (HAZ<-2.0) OR(95% CI)		Underweight (WAZ<-2.0) OR(95% CI)		Wasting (WHZ<-2.0) OR(95% CI)		Anemia (Hg<11.0g/dl) OR(95% CI)		Diarrhea in last 2 weeks OR(95% CI)	
	6-24 mo	*25-59 mo*	*6-24 mo*	*25-59 mo*	*6-24 mo*	*25-59 mo*	*6-24 mo*	*25-59 mo*	*6-24 mo*	*25-59 mo*
Any ASF	0.99 (0.63, 1.57)	0.80 (0.49, 1.31)	0.91 (0.52, 1.60)	0.84 (0.51, 1.37)	0.78 (0.39, 1.59)	1.16 (0.51, 2.63)	0.85 (0.52, 1.38)	**1.62 (1.02, 2.58)**	0.98 (0.59, 1.63)	1.20 (0.51, 2.79)
Child age (months)	**1.09 (1.05, 1.12)**	1.01 (0.98, 1.03)	**1.05 (1.01, 1.09)**	1.03 (1.00, 1.06)	1.02 (0.97, 1.06)	1.00 (0.96, 1.04)	**0.95 (0.92, 0.99)**	0.99 (0.96, 1.01)	1.00 (0.96, 1.04)	0.98 (0.93, 1.03)
Female child	**0.70 (0.51, 0.97)**	1.00 (0.61, 1.63)	**0.66 (0.45, 0.97)**	**1.78 (1.07, 2.97)**	0.72 (0.44, 1.19)	1.22 (0.56, 2.66)	1.00 (0.74, 1.35)	0.92 (0.57, 1.48)	1.16 (0.84, 1.60)	0.70 (0.30, 1.60)
Urban residence	1.50 (0.88, 2.55)	0.58 (0.21, 1.60)	0.93 (0.46, 1.89)	0.49 (0.18, 1.33)	0.94 (0.42, 2.08)	0.77 (0.20, 2.89)	0.79 (0.49, 1.28)	**0.38 (0.17, 0.86)**	1.30 (0.81, 2.07)	1.16 (0.56, 2.39)
Maternal age	1.02 (0.99, 1.04)	1.00 (0.96, 1.05)	1.00 (0.97, 1.02)	1.02 (0.97, 1.07)	0.98 (0.94, 1.01)	1.04 (0.98, 1.11)	0.97 (0.95, 1.00)	1.00 (0.96, 1.06)	**0.96 (0.94, 0.99)**	0.95 (0.84, 1.08)
Poorest Wealth Quintile	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Poorer	0.79 (0.52, 1.20)	0.70 (0.36, 1.37)	0.93 (0.57, 1.51)	0.73 (0.37, 1.46)	1.19 (0.67, 2.11)	0.86 (0.30, 2.47)	0.71 (0.41, 1.22)	1.10 (0.59, 2.06)	0.60 (0.35, 1.01)	1.44 (0.52, 3.98)
Middle	**0.60 (0.38, 0.94)**	1.00 (0.50, 2.02)	0.64 (0.36, 1.12)	0.80 (0.34, 1.86)	0.66 (0.31, 1.41)	0.66 (0.20, 2.20)	**0.52 (0.30, 0.92)**	0.58 (0.26, 1.26)	0.65 (0.38, 1.12)	0.98 (0.26, 3.66)
Richer	**0.39 (0.23, 0.68)**	0.75 (0.37, 1.53)	**0.48 (0.26, 0.88)**	0.71 (0.31, 1.68)	0.56 (0.27, 1.16)	0.65 (0.10, 4.10)	**0.46 (0.26, 0.81)**	0.90 (0.41, 2.00)	0.67 (0.36, 1.26)	0.47 (0.10, 2.12)
Richest	**0.19 (0.09, 0.40)**	0.60 (0.17, 2.19)	**0.31 (0.12, 0.79)**	0.55 (0.18, 1.68)	0.64 (0.26, 1.59)	0.93 (0.20, 4.39)	**0.35 (0.18, 0.67)**	0.56 (0.20, 1.59)	**0.48 (0.25, 0.90)**	**0.21 (0.07, 0.61)**
Maternal education (yrs)	1.02 (0.97, 1.08)	0.93 (0.86, 1.00)	1.01 (0.95, 1.08)	0.99 (0.92, 1.07)	0.97 (0.90, 1.05)	1.05 (0.91, 1.20)	1.00 (0.95, 1.06)	1.04 (0.97, 1.12)	0.96 (0.91, 101)	1.06 (0.95, 1.20)

[a] total sample for models: n=1967

* Values that are statistically signifcant at alpha level of 0.05 bolded

Key Findings

Undernutrition and Foodborne Illness Prevalence

- Anemia: high (66.74%)
- Stunting: moderate (29.66%)
- Underweight: moderate (21.61%)
- Diarrhea: Moderate (16.57%)
- Wasting: low (9.95%)

Complementary Feeding Practices

- Complementary feeding was 84.51% by 6 months
- 30.13% not in compliance with WHO recommendations

Consumption of Animal Source Foods

- Consumption of ASF was 77.22% and increased slightly with wealth, maternal education and urban residence

Stunting

- Slightly higher risk: older infants (6-24)
- Lower risk: female infants (6-24)
- Much lower risk: infants and children in wealthier households, especially infants (6-59)
- Slightly lower risk: children with educated moms (25-59)

Underweight

- Slightly higher risk: older infants (6-24)
- Much higher risk: female children (25-59)
- Lower risk: female infants (6-24)
- Much lower risk: infants and children in wealthier households, especially infants (6-59)

Anemia

- Much higher risk: Child consumption of ASF (25-59)
- Slightly lower risk: older infants (6-24)
- Slightly lower risk: female infants (6-24)
- Much lower risk: children in urban households (25-59)
- Much lower risk: infants in wealthier households (6-24)

Diarrhea

- Slightly lower risk: infants with older mothers (6-24)
- Much lower risk: infants and children in wealthier households (6-59)

Chapter 4: Discussion, Conclusions, and Recommendations

DISCUSSION

This study provides an overview of ASF consumption and child undernutrition among children ages 6-59 months who participated in the CDHS in 2014. Results indicate that consumption of ASF is not significantly associated with diarrhea, stunting, underweight, or wasting. Consumption of ASF is, however, significantly associated with an increased risk for anemia in children aged 25-59 months (OR=1.62; 95% CI 1.02, 2.58), contrary to reports in the literature (Murphy & Allen, 2003). It's important to note that ASF consumption was not significantly associated with anemia in children 6-24 months, and the observed relationship was in the opposite direction. The association between ASF consumption and anemia in children 25-59 months may be due to the non-specific nature of hemoglobin as a biomarker. The presence of anemia and the low hemoglobin levels may be attributed to non-nutritional causes as was indicated by a separate study using the micronutrient survey from the same CDHS 2014 dataset (Wieringa et al., 2016). Furthermore, data was only collected for the youngest child of the respondent, thereby limiting complete data on older children. The smaller dataset for children ages 25-59 months may not be representative and therefore may not illustrate a true association between ASF consumption and anemia. The lack of association between ASF and other indicators of undernutrition is also not consistent with the literature. Other studies have found that consumption of ASF was protective against stunting (Krebs et al., 2011) (Darapheak et al., 2013) and underweight (Darapheak et al., 2013). The Darapheak study, using CDHS 2005 survey data, had similar rates of ASF consumption across socioeconomic and geographic groups. However, Darapheak's study limited their population to 12-59 months and they adjusted for geographical area. Our study population ranged from 6-59 months, we did not adjust for geographical area, and we did adjust for child sex, age, and maternal age in addition to the covariates we shared with the Darapheak study. The differences in covariates might account for some of the difference in association with ASF consumption and health outcomes. It's also possible that the prevalence of health outcomes has consistently improved since reported in CDHS 2005 so the association may no longer be as strong as it once was. Consumption of ASF as an indicator might also be flawed because it is vulnerable to recall bias by the caretaker. The ASF indicator in this study did not factor in the quantity of ASF consumed, and only considered consumption of ASF as a binary variable.

Older infants (6-24 months) were at a higher risk for both stunting and underweight, but at a lower risk for anemia. The increased risk of stunting with age suggests that the window for successful intervention, typically defined as the first 1,000 days, diminishes and eventually disappears as young children get older (Ettyang & Sawe, 2016). Female infants were at a lower risk for stunting, underweight, and anemia. Therefore, being a female infant might be protective in this age group. This might be because there are increased iron requirements in males due to rapid gains in muscle mass (Antunes, Santos, Carvalho, Gonçalves, & Costa-Pereira, 2012). One study shows that males are more likely to become stunted in their first year of life, and females are likely to become stunted in their second year of life (Adair & Guilkey, 1997). Female children (25-59 months) were at a higher risk for underweight which might indicate that some effects of the chronic undernutrition persist as they age, but not to the point of stunting. This study also found that infants and children from wealthier households were at a lower risk for stunting, underweight, anemia and diarrhea. Overall, it can be deduced that relative wealth is associated with better growth outcomes in concordance with previous literature (Marriott, White, Hadden, Davies, & Wallingford, 2010) (Zanello et al., 2016). Similar studies have shown that stunting is more common among children who live in poor households (Ikeda et al., 2013). This study found that stunting in infants (6-24 months) was especially significantly associated with wealth. Another study of Cambodian children less than 2 that found that child's age, perceived birth size, family wealth status, and region of residence were also significantly associated with stunting (Ettyang & Sawe, 2016).

Although consumption of dairy has been linked to diarrhea in previous studies (Darapheak et al., 2013), there was no significant association between consumption of ASF and incidence of diarrhea in either age group. Infants with older mothers were significantly associated with a slightly lower risk for diarrhea.

This study found that children in urban households were also at a lower risk for anemia. Consumption of any ASF did not vary much by household or individual factors on the whole, although dairy and eggs were generally consumed in higher quantities in wealthier households. Consumption of any meat, however, was relatively consistent across most household and individual variables. Complementary feeding was largely consistent with WHO recommendations with 84.51% of sampled infants being fed solid, semi-solid or soft foods at 6-8 months in addition to being breastfed. There remained 30.13% of children that did not follow WHO recommendations for introduction of complementary feeding because they introduced complementary foods too early (14.64%) or too late (15.49%). It is important that once complementary feeding begins that it provides adequate nutrition for growth. In poor settings, the quality of the complementary foods being provided might be compromised during this critical window for child growth. According to one study, much of the complementary feeding from 6-23 months in Cambodia is provided solely by watery, rice porridge that fails to meet nutritional needs (Reinbott et al., 2016). Therefore, the percent of children 6-8 months does not adequately convey the quality of foods they are receiving so they may still be at risk for undernutrition.

Limitations

This study is limited due to the cross-sectional nature of the survey design. Temporal or causative effects cannot be determined from this data, only inferred. This study relies only on associations between exposures and outcomes to draw meaning. Additionally, because the survey only asks about food consumption for the youngest child of the respondent, the sample is skewed towards younger ages and there is a lack of data on older children. For complementary feeding, the quality and the timing of introduction, are both important. This study only looked at the occurrence of complementary feeding and did not investigate the quality of complementary foods, therefore that is a key area for future research. Finally, this study did not look at the quantity of ASF consumed, and it was treated as a binary variable. Data on the amount of ASF consumed might illustrate a clearer relationship between ASF consumption and undernutrition, anemia, and diarrhea. Consumption of animal source foods in the last 24 hours might also be too vague and broad of an indicator to have much predictive power.

CONCLUSIONS

Prevalence of anemia, stunting, and underweight remain high among children 6-59 months in Cambodia in 2014. Additionally, consumption of ASF is remarkably high across social and geographic variables, but it was not significantly associated with a lower risk of undernutrition. Consumption of ASF was associated with higher risk of anemia in children 25-59 months, contrary to previous literature. Wealth index was the strongest predictor for nutritional indices and was especially associated with a lower risk of stunting, underweight, anemia, and diarrhea.

RECOMMENDATIONS

This study adds to the growing body of work that asserts that socioeconomic factors strongly affect undernutrition, providing additional evidence that comprehensive economic programs could ameliorate undernutrition in low and middle income countries. Additionally, any targeted efforts to address more proximal causes of undernutrition would be maximized if focused on lower wealth quintiles. Therefore, nutrition-specific and nutrition-sensitive programs would be required to comprehensively address the poverty-embedded problem of undernutrition in Cambodia.

Additional research is needed to examine the quality of complementary foods upon their introduction and the quantity of ASF consumed, to better understand the relationship between ASF consumption and undernutrition.

This study showed the effect of wealth inequality on undernutrition in children but did not focus on gender inequality within the household. It would be beneficial to understand household food politics because maternal autonomy and maternal nutrition are strong predictors of child health (Ettyang & Sawe, 2016) (V. Greffeuille et al., 2016). A study of this nature would likely need to be undertaken on a different dataset that looks at households comprehensively, because DHS does not collect data that would reflect intra-household inequalities.

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