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Yale SCHOOL OF PUBLIC HEALTH

Master's Thesis

Predictors of Nutritional Status among Young Samoan Children

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Abstract

The nutrition transition is associated with the rising burden of non-communicable diseases in low-and middle-income countries and in Samoa, young children are particularly vulnerable to malnutrition in various forms. In this present study, we documented the current prevalence and co-existence of child nutritional status outcomes within this population and by census region. We then examined the role of selected child, maternal, and household characteristics as potential predictors of child nutritional status. A cross-sectional, community-based design was used to collect data from singleton pairs of a non-pregnant mother and child between 24 to 59 months olds in the Samoan island of Upolu. Sixty-two out of 305 surveyed children (20.3%) were moderately or severely stunted (HAZ< -2SD), 16.1% were overweight/obese (BMIZ> 2SD), 2.3% were underweight (WAZ< -2SD), and 33.1% were anemic (Hb< 11.0 g/dL). Among the overweight/obese children, 28.6% were also classified as stunted and 42.9% anemic. Census region was not significantly associated with any child nutritional status outcome. Childhood stunting was significantly associated with being female and increased Vitamin C intake, while overweight/obesity was associated with higher family socio-economic status and decreased sugar intake. Child anemia was associated with increased age and having an anemic mother. This analysis identified no common predictors of nutritional status, highlighting the importance of different interventions that address specific forms of malnutrition in this age group. Remarkable levels of stunting, overweight/obesity, and anemia among young children suggest that it is critical to invest in nutrition and scale up health programs targeting early child development in Samoa.

Keywords

Nutritional status;
Young children;
Nutrition transition;
Undernutrition;
Obesity;
Low- and middle-income country.

Key Messages

- There is a moderate prevalence of stunting (20.1%), overweight/obesity (16.1%), anemia (34.1%), and low prevalence of underweight (2.3%) in children aged 24-59 months in Upolu, Samoa
- A dual burden of malnutrition is apparent in young children, with 28.6% of the overweight/obese children also classified as stunted and 42.9% anemic
- No common predictors for any child nutritional status outcome were detected
- Different nutrition-specific interventions may be needed to improve different nutritional status outcomes in this age group

Introduction

The nutrition transition, underlined by economic development, modernization, and rapid urbanization (Popkin, 1998), has perpetuated the disproportionately high burden of non-communicable diseases (NCDs) in low- and middle-income countries (LMICs) (Popkin, 2006). Patterns of diet and physical activity have shifted toward increased consumption of high-calorie, nutrient-poor foods and increased sedentary activity, resulting in chronic energy imbalances and poor nutritional outcomes (Popkin, 2004). The adverse health effects associated with the nutrition transition is often greatest in children under five years of age (Drewnowski and Popkin, 1997). Changes in lifestyle often threaten appropriate development and growth in the early life stages, contributing to a higher risk of malnutrition in various forms (UNICEF et al., 2015) and premature NCD mortality (Anderson, 2013). Particularly in young children, malnutrition has been closely linked with increased mortality (Pelletier et al., 1995) and impaired cognitive, physical and metabolic development (Walker et al., 2007).

Samoa serves as an example of a LMIC in the South Pacific undergoing significant nutrition transition, with tremendous shifts in societal and dietary structures along with significant rises in NCD prevalence recorded over the past two decades (Baker et al., 1986, Keighley et al., 2007, McGarvey, 1991). High levels of obesity and other associated metabolic disorders have been well-documented among the Samoan adult population (Hawley et al., 2014, Seiden et al., 2012, DiBello et al., 2009). A high prevalence of overweight and obesity has also been observed among Samoan school-age children. Data from 2003 showed 14.8% of boys and 6.3% of girls aged 6-8 years old to be overweight, while 3.3% of boys and 14.3% of girls were already obese(Keighley et al., 2007). While the burden of NCD is clear among adults and school-age children, there remains a paucity of data for children under five years of age.

Present knowledge of child nutritional status relies on data from the Samoa National Nutrition Survey conducted 16 years ago (1999) (Mackerras and Kiernan, 2003). Data from that survey showed that 4.2% of children under 5 years of age were classified as stunted and 1.9% were underweight. At the same time, 10.6% of children aged 2-4 years were overweight or obese, 23.2% were anemic in the population surveyed (Mackerras and Kiernan, 2003). The National Nutrition survey reported that these levels indicated no substantial problem of undernutrition, overweight or obesity, and a moderate level of iron deficiency. In addition, it remains unclear how child, maternal, and socio-economic factors, which are well-established determinants of child health and survival in other settings, are associated with childhood nutritional status in Samoa([Samoa] et al., 2010). Since dramatic rises in obesity and concurrent problems with malnutrition have been identified in Samoan adults and school-aged children over the past 20 years (Keighley et al., 2007, Seiden et al., 2012, Hawley et al., 2014, (NCD-RisC), 2016), a reassessment remains warranted in young children.

This study serves to document the current nutritional status of children between between 24 to 59 months old and identify common predictors for the spectrum of malnutrition to address this current knowledge gap in Samoa. We first describe the prevalence and coexistence of child stunting, overweight/obesity, anemia, underweight, and then, compare the prevalences between three census regions with varying levels of urbanization. We further examine associations between various child, maternal, and household characteristics and child nutritional status in this setting. Understanding the determinants of malnutrition in various forms is critical to inform future NCD control and prevention strategies targeted at this age group. Obesity and micronutrient deficiencies, each is itself problematic, but in combination contributes to the development and severity of comorbidities and related NCD(Garcia et al., 2009).

Methods

Study population and participants

Our study population is derived from the independent, lower-middle income nation of Samoa. In 2011, Samoa had an estimated population of 187,820 with approximately 14% <5 years of age and 47% women aged 15-49 years((SBS), 2011). Majority (76%) of the population resides on the island of Upolu, where there is substantial heterogeneity in the way of life ((SBS), 2011). Half (52.0%) of the rural, economically active persons over the age of 15 years produce subsistence for use or sale, while most urban residents are employees (73.4% and 60.2%, respectively) ((SBS), 2011). More urban residents live in a closed European households compared to rural residents (54.6%, 32.8%, and 23.0%, respectively)((SBS), 2011).

The wide variation in lifestyles among Samoans is mostly the result of rapid economic modernization and associated nutrition transition (Keighley et al., 2007, DiBello et al., 2009, McGarvey, 1991). In order to understand whether child nutritional status is influenced by these processes, the study aimed to sample approximately 100 mothers aged 18 to <64 years with a child between 24-59 months from villages within the three census regions: Rest of Upolu (ROU), Northwest Upolu (NWU), and Apia Urban Area (AUA). These regions will be referred to in this paper as the rural, peri-urban, and urban region, respectively.

The recruitment and measurement of the study participants took place from June to August 2015. Ten villages were included in the study: three from ROU, three from NWU, and four from AUA. For the ease of data collection, large villages with a population greater than 500 were targeted, paying close attention to geographic distribution. The Ministry of Health and the Samoan Bureau of Statistics arranged for village level permission to spend 2-3 days in each village completing study activities. Recruitment within villages was undertaken with the cooperation of village leaders and women's committee representatives, whose role was to explain the purpose and procedures of the study to women residing in the village and promote interest in participation. The women and children who attended the data collection days were voluntary residents of the local village who chose to participate. The study site was a centrally located building in the village. A field team of two investigators from Yale University, one investigator from University of Michigan, and two locally trained field assistants conducted the data collection.

A total of 319 mother and child singleton pairs in the target age range participated in the study. Eligible children were of Samoan origin, and had four Samoan grandparents based on maternal-report. Eligible mothers were non-pregnant, with no severe physical or cognitive impairment, and willing and able to complete the interview portion of the study. A total of 14 enrolled participants were later excluded: 4 based on the inclusion criteria (two children were under 24 months old and two children were born premature) and 10 based on a lack of complete physical measurements.

Physical Measurements

Anthropometric measures were taken from both mothers and children, with all participants in light clothing. Standing height was measured to the nearest 0.1 cm using a portable stadiometer (Pfister Imports, NY), and weight to the nearest 0.1 kg using a Tanita HD 351 digital weight scale (Tanita Corporation of America, IL). Duplicate measures were averaged for use in analyses. A random, small finger-prick blood hemoglobin (Hb) sample was also taken using AimStrip Hb test system (Germaine Laboratories Inc., TX).

Child Nutritional Status Outcomes

The 2006 WHO growth standards were used to construct a dichotomous measure of stunting, overweight/obesity, and underweight, to distinguish whether or not a child had adequate nutritional status. Children whose height for age z score is below -2 SD, or body-mass-index (BMI) for age z score is above 2 SD, or weight for age z score below -2 SD from the median of the reference population are considered stunted, overweight/obese, and underweight, respectively (de Onis, 2006). Child anemia was defined as having Hb levels below 11.0 g/dL (WHO, 2011).

Selected Child, Maternal, and Household Characteristics

A questionnaire, administered in Samoan to all mothers, collected detailed information on selected child, maternal, and household characteristics that may potentially associated with child nutritional status. Child characteristics included health history, infant feeding practices (breastfeeding and medication use), nutrition, and maternal-report physical activity. A dietary screener was used to assess the child dietary behaviors, including eating daily breakfast, and specific-food group consumption, such as eating frozen weekly desserts. No locally relevant physical activity questionnaire has been developed for use in this population, therefore we used the Netherlands Physical Activity Questionnaire for Young children (NPAQ) (Janz et al., 2005). Mothers were asked to describe their child compared to other children on a Likert 5-point scale and the answers were summed to calculate a physical activity score. This physical activity score was coded into tertiles: 0 through 27 (n=109), 28 through 29 (n=84), and 30 through 35 (n=112).

Various maternal demographics were recorded, including age, highest level of education attained, and marital status. Maternal weight status was classified as either normal or overweight/obese based on the Polynesian BMI cutoffs(<26 kg/m^2 and ≥26 kg/m^2, respectively), which are sensitive to the greater lean mass per kilogram in the adult Polynesian population (Swinburn et al., 1999). Maternal anemia was defined as having Hb levels below 12.0 g/dL (WHO, 2011).

For household characteristics, mothers were asked to select from 5 category ranges of annual household income, based on the 2011 Samoa Census Report ((SBS), 2011). Income was dichotomized into less than $10,000 tala, and $10,000 tala or more. A material lifestyle score (MLS) was calculated for each household based upon a 18-point summary index, which assessed possession of fridge, freezer, stereo, portable stereo, microwave oven, rice cooker, blender, sewing machine, television, VCR/DVD, couch, washing machine, landline telephone, computer/laptop, tablet, electric fan, air conditioner, and motor vehicle. This type of index is a sensitive measure of family socio-economic status in modernizing societies, and has been previously used to study the adult Samoan population (DiBello et al., 2009). MLS was coded into quartiles of the score distribution: 0 through 2 (n=63), 3 through 4 (n=68), 5 through 7 (n=97), and 8 through 18 (n=77). These quartiles are referred to as low, medium, high, and very high MLS, respectively. Community spirit of the household village was measured using a Likert 5-point scale question from an adult Samoan GWAS study (Hawley et al., 2014), and categorized as either weak, average, or strong.

Child Dietary Intake

Dietary intake was assessed using a 104-item Food Frequency Questionnaire (FFQ) with a 30-day reference period. The questionnaire was based on a validated 2002-2003 version used in Samoa and American Samoa (DiBello et al., 2009) and updated to include newly available foods. The frequency of intake of individual items was measured across seven categories ranging from never/less than once per month to more than six times per day. Daily intake of total energy and nutrients was computed by multiplying the daily consumption frequency of each food by the nutrient content of a fixed, standard portion size. The nutrient content of FFQ items were based on the USDA Food Composition Tables (USDA, 2012) with complementary information from the FAO Pacific Island food composition tables (Dignan et al., 2004) used for locally produced items.

Total protein and carbohydrate (grams) were multiplied by four calories, and fat by nine, to obtain the total energy (calories) from each macronutrient the child participant had consumed. Macronutrient calories were divided by total calories to estimate the percentage of total energy from each macronutrient.

Specific-nutrient intake was log-transformed and adjusted for the log-transformed total energy using the residual method (Willett et al., 1997), to estimate the amount of nutrient intake per day among the child participants. Adjustment for total energy intake (TEI) was used in order to control for confounding, reduce extraneous variation, and predict associations between dietary intake and child nutritional status outcomes (Willett et al., 1997).

Statistical Analysis

Data were analyzed using SAS version 9.4 (SAS Institute Inc., NC). Our final study sample is restricted to 305 children for whom complete information is available with regard to nutritional status. Sample characteristics and TEI-adjusted dietary intakes are described on a geographic basis, in order to understand the variation between census regions in the Samoan island of Upolu. For analyses, characteristics were dichotomized and coded as described above. To test for differences in means or distribution of child, maternal, and household characteristics by census region and child nutritional status outcome, we used Chi-square (χ^2) test for categorical variables and analysis of variance or independent sample *t* tests for continuous variables. Generalized linear models (Proc GLM in the Statistical Analysis System) were used to adjust macronutrient intakes as a percentage of energy for census region and child nutritional status outcomes. In the multivariable logistic regression models for the prediction of child nutritional status outcomes, TEI and nutrient intake were entered as continuous terms, and categorical terms were entered for census region, age group, and gender. A backward elimination strategy and likelihood ratio χ^2 test was used to generate the most parsimonious model with child, maternal, and household characteristics that remained significant at the 0.10 level. *P*-values less than 0.05 were considered statistically significant.

Ethics

This study received ethical approval from the Yale University Institutional Review Board, Human Investigation Committee (Protocol: 1504015775) and permission by the Ministry of Health Samoa and

Bureau of Statistics. Participation in the study was voluntary, and all mothers gave written informed consent for both their own and their child's involvement in the study.

Results

Characteristics of the study population

Mean ages of young children and mothers were 40.0±10.2 months and 33.8±9.6 years, respectively. The proportion of singleton mother-child pairs was similar across the rural ROU (n=103), peri-urban NWU (n=102), and urban AUA (n=100) region.

Table 1 presents the characteristics of the children and mothers included in the study sample by census region. The distribution of child age and gender did not differ between census regions. Based on data from the dietary screener, children living in the rural region were characterized by higher frequency of fruit and vegetable consumption compared to those in the urban region (both $p<0.01$, Table 1). They were also more active, based on their NPAQ scores than children in the other regions. Urban children had the highest mean total screen time (90.5±60.0 minutes/day).

Maternal age, marital status and the proportion of mothers who were classified as overweight/obese did not differ between census regions. Level of maternal education did vary by census region, with the least high school graduates in the rural region (48.5%) and the most in the urban (70.0%). Urban households were wealthier and had higher MLS compared to those in the peri-urban and rural region.

Daily child dietary intake, based on the FFQ, is presented in Table 2. Mean daily TEI was significantly different across the three census regions, with the children living in the rural region having the lowest intake ($p<0.001$, Table 2). Compared to the rural children, those living in the peri-urban region consumed a lower proportion of their TEI from protein, a higher proportion from carbohydrates ($p<0.001$) and consumed more sugar. TEI-adjusted, mean daily intake of Vitamin C and calcium were greatest among peri-urban children (276.4±90.5mg, and 814.0±163.4mg, respectively); however, the mean daily cholesterol and sodium intake were greatest among rural children (393.2±112.8mg and 3236.5±680.6mg, respectively). Other micronutrients such as iron, potassium, and vitamins A and C did not differ by region.

Child Nutritional Status and unadjusted associations with child, maternal and household characteristics

The overall prevalences of stunting, overweight/obesity, and anemia were 20.3% (n=62), 16.1% (n=49), 34.1% (n=104), respectively (Table 3). Merely seven children were underweight (data not shown) and associated characteristics are not described in this paper. Despite differences in child, maternal and household characteristics described above, census region was not significantly associated with any nutritional status outcome.

Unadjusted associations showed that stunting was most prevalent among children who were 24-35.99 months old, boys, those who were not breastfed, ate daily breakfast, did not eat weekly frozen desserts, had mother who was not a high school graduate, and lived in a household with an annual income less than $10,000 tala.

Child overweight/obesity prevalence did not differ by any child or maternal characteristics, but was associated with household MLS ($p=0.030$). More overweight/obese children were living in households with the very high MLS compared to those with the low MLS (26.0% compared with 7.9%; $p=0.030$).

The prevalence of anemia was highest among children who were 24-35 months old. Anemia was significantly more prevalent among children with an anemic mother than those without ($p=0.002$). Married mothers had a lower proportion of anemic children compared to those who are not married (43.8% compared with 31.0%, $p=0.044$).

Few dietary intake measures were associated with the child nutritional status outcomes (Table 4). Notably, mean daily TEI was not associated with any of the outcomes. Adjusting for TEI, stunted children consumed approximately 250mg more potassium than those who were not stunted, overweight/obese children consumed slightly less sugar (12.4g) and more iron (~1mg) than those who were not, and there were no significant associations between those with and without anemia, although calcium intake was marginally higher in anemic children (p=0.091).

Predictors of Child Nutritional Status

Multivariable logistic regression models were generated to identify independently significant predictors of each child nutritional status outcome, as shown in Table 5. Each model was adjusted for census region, child age, gender, TEI, and any child, maternal or household characteristic associated with the outcome of interest at the level of 0.10 in the unadjusted analyses.

Odds of child stunting was approximately 59% lower for females compared to males, after adjusting for other characteristics (p=0.006). Children who ate frozen desserts at least weekly had a 70% lower odds of stunting compared those who did not (p<0.001). For every 10 mg increase in daily vitamin C, we expect a 4% increased odds in stunting on average (p=0.046). Eating breakfast daily also increased the odds of stunting (OR: 2.09, 95% CI: 0.93, 4.68), but this did not remain significant (p=0.073).

Child overweight/obesity remained significantly associated with MLS when controlling for other characteristics (p=0.016). Children with very high MLS had nearly quadruple the odds of overweight/obesity compared to those with the low MLS (OR: 3.61, 95%CI: 1.22,10.71). Based on the multivariable model, the odds of overweight/obesity are expected to increase by 16% for every 100 mg increase in daily calcium intake (p=0.056), and decrease by 11% for every 10 g increase in daily sugar intake (p=0.032).

After adjusting for other characteristics, odds of child anemia decreased with age. Among children aged 48-59.99 months, the odds were 75% lower than among those who were 24-35.99 months (p<0.001). For every 100 mg increase in daily calcium intake, the odds of anemia is expected to increase by 14%(p=0.052). Children with a married mother had a lower odds of anemia (OR:0.60, 95%CI:0.34,1.07) compared to those with single mothers, although this did not remain significant (p=0.084). Child anemia remained significantly associated with maternal anemia (p=0.007), with children with an anemic mother having more than twice the odds of anemia compared to those whose mothers had hemoglobin levels within the healthy range (OR:2.20, 95%CI:1.22, 3.98). For every 100 mg increase in daily calcium intake, the odds of anemia is expected to increase by 14% (p=0.052).

Dual burden of Malnutrition

Although levels of stunting and anemia did not significantly differ between children who were overweight/obese and those were not (p=0.118 and p=0.175, respectively), among the forty-nine overweight and obese children, 28.6% (n=14) were also classified as stunted and 42.9% (n=21) were anemic (data not shown). Of the sixty-two children who were stunted, 48.4% (n=30) were anemic, however this proportion of anemia was significantly lower than in those were not stunted (51.6%, n=32) (p=0.008).

Discussion

Adequate nutritional status is critical for child growth, development, and health later in life. The prevalence of stunting (20.3%), overweight/obesity (16.1%) and anemia (34.1%) found in this study is remarkable, and substantially higher than that reported in the 1999 National Nutrition Survey. The sample of the National Nutrition Survey included children living on the second, most rural, Samoan island of Savai'i which means that their findings may not be directly comparable with our study; however, the differences in prevalence of the child nutritional status outcomes suggest that continuing modernization, urbanization, and the associated nutrition transition may be negatively impacting the health of children in this age group across all regions of Samoa.

Stunting, defined as low height-for-age(de Onis, 2006), reflects chronic undernutrition during the most critical periods of growth and development in early life. Overall, the prevalence of stunting observed in this study was very consistent with reports from other Pacific Island nations: 48% of children under 5 years of age are reportedly stunted in Papua New Guinea, 33% in the Solomon Islands, and 26.3% in Vanuatu (Grieve et al., May 2013). The majority of the Samoan children who were classified as stunted were in the youngest age group of 24-35.99 months; while, there was no stunting in the oldest age group. Although these data are cross-sectional, they suggest that Samoan children may regain position on the WHO height growth charts as they get older. As such, we hypothesize that the low height-for-age observed in the youngest age group of our sample may not be pathological and instead, possibly reflects a pattern of growth different than that observed among the 2006 WHO reference group. This hypothesis requires exploration with longitudinal data and further information on the potential consequences of this pattern of growth for later health and cognitive development.

Young girls in our study had decreased odds of stunting. This finding is consistent with studies in many other settings globally (Wamani et al., 2007, Hien and Kam, 2008, Foster et al., 2005) and across the Pacific, including Papua New Guinea (Decaro et al., 2010) and Vanuatu (Grieve et al., May 2013). Our data did not suggest that this was a result of different infant feeding practices or current nutritional status, and there is little evidence from the Pacific to suggest that daughters are preferred (Marshall, 1985) although this has not been exhaustively explored in contemporary populations. It has, however, been argued that improved growth among female children may reflect their relative resilience to adverse *in utero* environments, seasonal fluctuations in nutritional availability, and infectious disease compared to males (Stinson, 1985, McDade et al., 2008, Decaro et al., 2010)

Eating frozen desserts at least weekly was also protective of child stunting; however, we suspect that this may reflect higher family socioeconomic status and the child's overall caloric intake, rather than specific nutritional content obtained from the desserts. Consuming frozen desserts, such as ice cream, at least weekly was associated with higher MLS and mean daily TEI (data not shown). Contrary to the existing literature (Simeon and Grantham-McGregor, 1989, Rampersaud et al., 2005, Black et al., 2008), stunting was positively associated with the child eating breakfast daily and the daily intake of vitamin C. These findings are difficult to explain and warrant further investigation. There are inherent limitations of dietary intake estimation based on FFQs (Burrows et al., 2010, Roman-Vinas et al., 2010), which may have contributed to these findings, as we were not able to determine the dietary composition of breakfast specifically and estimates of micronutrient intake are prone to error. Additionally, we were not able to account for reverse causality. Our questionnaire did not collect information on any physician or well-child visits. Child growth may slow during or after illness, if additional nutrient requirements associated with the illness are not met by feeding practices (Paintal and Aguayo, 2016). The low height-for-age among the stunted children in our sample may have already been detected by physicians, and parents advised to increase dietary intake.

Looking at the opposite end of the spectrum of malnutrition, our study found problematic levels of childhood overweight/obesity, especially since overweight children are at known risk of becoming overweight adolescents and adults (Ng et al., 2014), and experiencing metabolic dysregulation in later life (Anderson, 2013). Estimates of overweight/obesity among the young children in Pacific Island nations are difficult to compare with different classifications for weight status, such as weight for height, weight for age, or BMI for age (de Onis, 2006). However, in American Samoa, who are further along in the nutrition transition, it is estimated that approximately 35% of children under 5 are overweight/obese (WIC, 2009). The strongest predictor of overweight/obesity in our sample was the household MLS. High family socio-economic status increased the odds of overweight/obesity among young children, a pattern that is also similar among adults in this setting (Seiden et al., 2012, Keighley et al., 2007, DiBello et al., 2009). In Vanuatu, and many other countries undergoing the nutrition transition (Dancause et al., 2012) higher SES is also associated with child overweight. High BMI for age often results from a positive chronic energy balance (UNICEF et al., 2015, de Onis, 2006), but there were no differences observed between maternal-reported physical activity and mean daily TEI of young Samoan children who were overweight/obese and those who were not in our study. Furthermore, there were no differences in the proportion of calories consumed from macronutrients (protein, carbohydrates and total fat) between the two groups. Interesting, total energy-adjusted calcium intake increased the odds of overweight/obesity, consistent with the suggestion that dietary calcium intake may positively influence energy balance particularly in overweight/obese children (Astrup, 2008). Dietary sugar intake was very high among children in our sample and was unusually protective of overweight/obesity; however, this finding should be interpreted with extreme caution as we cannot differentiate between added versus natural sugars in food consumed by the child with our questionnaire. Local fruits and vegetables, and starchy staples in the traditional Pacific Island diets are very carbohydrate-dense (Dignan et al., 2004) and these natural sugars contribute significantly to overall daily sugar intake. Commercial, processed food and beverage products may be nutritionally detrimental, potentially increasing dietary consumption of added sugar and displacing consumption of other more nutritious options in early years of life (Seiden et al., 2012, Pries et al., 2016).

Our data identified more than one-third of the study sample (children and mothers) as having some degree of anemia. We included mild anemia in our outcome, as the WHO cautions that even mild levels of anemia may be problematic for growth and development in children under 5 (WHO, 2011). The prevalence of anemia among the Samoan children was again consistent with estimates from other countries across the Pacific region. In the Solomon Islands, 48% of children 6-59 months are anemic (Grieve et al., May 2013), while more than half of children of the same age group are anemic in Nauru (Nauru Bureau of Statistics, 2009)and Tuvalu (Grieve et al., May 2013). The estimated prevalence of any anemia was highest in the youngest children aged 24-35.99 months, and the odds of anemia decreased with age as in the other Pacific Island settings (Nauru Bureau of Statistics, 2009, Grieve et al., May 2013). The odds of any anemia was nearly 120% higher among children with an anemic mother compared to those without, as expected based on the strong evidence revealing the intricate relationship between maternal and child nutritional status (Tzioumis and Adair, 2014). Having a married mother was protective of child anemia and this supports the link between good health and nutrition behaviors in children with social support provided through marriage(Schafer et al., 1999, Combs-Orme et al., 2003). Increasing calcium intake increased the odds of child anemia and this borderline significant finding likely reflects the competition between calcium with iron for absorption in the body which can adversely impact hemoglobin levels (Bailey et al., 2015). While iron deficiency is the most common nutritional source of anemia in young children (Lopez et al., 2016), our study did not recognize any association between the two. Multiple nutrient deficiencies and helminth infections such as hookworms can result in anemia (Kassebaum, 2016) and further investigation is urgently needed to determine the source of anemia among these young children. A recent study suggested that hookworms were present in the feces of almost all dogs in Samoa (97.5%)(Sjölander, 2012), and with a large and increasing population of stray dogs, this may represent a major public health concern.

Our finding of co-existing levels of child stunting, overweight/obesity, and anemia highlight the vulnerability of young Samoan children to the malnutrition in various forms. Only seven children were classified as underweight in this study. As in other LMICs undergoing the nutrition transition, it is common to find a dual burden of malnutrition: undernourishment and micronutrient deficiencies, co-existing with the other extreme of overweight obesity and other diet-related chronic diseases (Eckhardt, 2006, Doak et al., 2005). Previous studies have consistently shown an association between childhood stunting and anemia (Tzioumis and Adair, 2014, Lopez et al., 2016, Bailey et al., 2015). Especially among the poor and living in environments with insufficient sanitation, children are at higher risk of infection and micronutrient deficiencies (Bailey et al., 2015). While the global prevalence of undernutrition has decreased between 1990-2012, the number of countries with equivalent levels of stunting and overweight among children under 5 years has increased substantially (Tzioumis et al., 2016).

No common predictors of child nutritional status outcomes were observed in this study. Surprisingly, many of the selected characteristics were not associated with nutritional status and this may be accounted for by the inherent limitations in our cross-sectional approach. Physical activity is a well-established determinant of child health, however it is difficult to measure indirectly in young children by maternal-report (Adamo et al., 2009). Levels of activity may have been over-reported by mothers, especially if a child was perceived as being very active (Hesketh et al., 2013). While causal inferences cannot be determined, this study identified unique characteristics associated with child nutritional status outcomes, which may be targeted in existing nutrition-sensitive approaches and different nutrition-specific interventions (Hawkes et al., 2015).

To our knowledge, this is the first regional study directly measuring stunting and anemia prevalence in association with overweight/obesity status in children. Poor nutrition that is manifested in all forms of malnutrition has lifelong implications, reducing a child’s ability to learn and grow to their full potential, and can lead to decreased productivity and weaker long-term national economic performance (UNICEF et al., 2015, Hawkes et al., 2015). The global community should engage in the development of better nutrition-related NCD control and prevention strategies that target undernutrition and overweight/obesity simultaneously in this age group. An investment in nutrition is foundational for human development and will help to ensure good health throughout the life course.

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Table 1. Description of the study population by census region*

Characteristics	Total (n=305)	Rest of Upolu (n=103)	Northwest Upolu (n=102)	Apia Urban Area (n=100)	P†
Child					
Age (months)					0.941
24-35.99	122 (40.0)	40 (38.8)	39 (38.2)	43 (43.0)	
36-47.99	103 (33.8)	36 (35.0)	34 (33.3)	33 (33.0)	
48-59.99	80 (26.2)	27 (26.2)	29 (28.4)	24 (24.0)	
Female	148 (48.5)	45 (43.7)	50 (49.0)	53 (53.0)	0.412
First Child	75 (24.6)	25 (24.3)	27 (26.5)	23 (23.0)	0.845
Birth weight (kg)[a]	3.6 ± 0.5	3.6 ± 0.6	3.6 ± 0.5	3.6 ± 0.6	0.868
Ever Breastfed	208 (68.2)	63 (61.2)	74 (72.6)	71 (71.0)	0.165
Reported illness in the past 3 weeks	29 (9.5)	6 (5.8)	11 (10.8)	12 (12.0)	0.281
Deworming medication use in the past 3 weeks	59 (19.5)	16 (15.7)	18 (17.8)	25 (25.3)	0.201
Eats daily breakfast in the past week[b]	202 (66.2)	71 (68.9)	67 (65.7)	64 (64.0)	0.751
Eats fruit (times/week)[b]	7.3 ± 6.6	9.0 ± 8.4	6.0 ± 4.9	6.9 ± 5.5	0.003
Eats vegetable (times/week) [b]	7.5 ± 5.7	9.2 ± 6.1	7.0 ± 5.4	6.4 ± 5.2	0.001
Drinks sweetened fruit juice (times/week) [b]	0.2 ± 0.7	0.1 ± 0.4	0.3 ± 0.8	0.3 ± 0.8	0.150
Eats frozen dessert (times/week) [b]	1.8 ± 1.8	1.6 ± 1.4	1.7 ± 1.5	2.1 ± 2.2	0.059
Nighttime sleep (hours/ day)	9.5 ±1.0	9.3 ± 0.7	9.5 ± 0.9	9.7 ± 1.4	0.034
Total screen time (minutes/day)[c]	79.9 ± 55.9	87.9 ± 55.2	61.5 ± 47.7	90.5 ± 60.0	<0.001
Physical Activity Score (NPAQ)[d]					0.014
Tertile 1 (mean: 24.1, SD:3.8)	109 (35.7)	31 (30.1)	44 (43.1)	34 (34.0)	
Tertile 2 (mean: 29.1, SD: 0.7)	84 (27.5)	24 (23.3)	34 (33.3)	26 (26.0)	
Tertile 3 (mean: 32.0, SD: 1.2)	112 (36.7)	48 (46.6)	24 (23.5)	40 (40.0)	
Mother					
Age (years)	33.9 ± 9.6	32.0 ± 8.9	34.6 ± 9.4	34.9 ± 10.3	0.054
High school graduate[e]	184 (60.3)	50 (48.5)	64 (62.8)	70 (70.0)	0.007
Married or cohabitating	232 (76.1)	82 (79.6)	78 (76.5)	72 (72.0)	0.443
Overweight/Obese (BMI≥ 26 kg/m^2)	266 (87.2)	89 (86.4)	87 (85.3)	90 (90.0)	0.579
Anemia (Hb> 12.0 g/dL)	69 (22.7)	34 (33.3)	16 (15.7)	19 (19.0)	0.006
Household					
Annual income less than $10,000 tala	238 (78.3)	87 (84.5)	85 (83.3)	66 (66.7)	0.003
Material lifestyle score[f]					<0.001
Quartile 1, (mean: 1.3, SD: 0.8)	63 (20.7)	23 (22.3)	25 (24.5)	15 (15.0)	
Quartile 2, (mean: 3.5, SD: 0.5)	68 (22.3)	28 (27.2)	23 (22.6)	17 (17.0)	
Quartile 3, (mean: 5.9, SD: 0.8)	97 (31.8)	37 (35.9)	34 (33.3)	26 (26.0)	
Quartile 4, (mean: 10.5, SD: 2.8)	77 (25.3)	15 (14.6)	20 (19.6)	42 (42.0)	
Community spirit					0.033
Weak	7 (2.3)	4 (3.9)	0 (0.0)	3 (3.0)	
Average	147 (48.4)	40 (38.8)	58 (56.9)	49 (49.5)	
Strong	150 (49.3)	59 (57.3)	44 (43.1)	47 (47.5)	

BMI,body mass index; *Hb*,hemoglobin.
* Values given are frequency counts and column percentages in parentheses or mean ± SD. Numbers may not sum to totals due to missing data, and percentages may not sum to 100% due to rounding.
† P-values for analysis of variance F-test (for continuous variables) or χ^2 (for categorical variables) test.
[a] Twenty-three mothers did not know their child birth weight and were excluded from this sample mean.
[b] Child dietary behaviors and specific-food group consumption were based on data from the dietary screener.
[c] Total screen time is the sum of the reported minutes spent watching TV, on the computer, or phone.
[d] Physical activity score is the sum of items from the Netherlands Physical Activity Questionnaire for Young Children (NPAQ). The score is out of a maximum of 35, with higher scores indicating greater physical activity.
[e] High school graduates include mothers who reported completing college, university or higher education.
[f] Material lifestyle score is a sum of all consumer durables owned. The score is out of a maximum of 18, with higher scores indicating higher material lifestyle.

Table 2. Daily energy, macro-, and micro-nutrient intake of child participants by census region*

	Total (N=305)	Rest of Upolu (n=103)	Northwest Upolu (n=102)	Apia Urban Area (n=100)	P†
TEI (kcal)	3369.6 ± 2614.0	2611.0 ± 1659.4	4531.6 ± 3463.9	2965.8 ±1936.4	<0.001
Macronutrient intake					
Total protein *(% E)*	14.4 ± 3.6	15.7 ± 5.7	13.2 ± 5.9	14.4 ± 5.7	<0.001
Total carbohydrates *(% E)*	52.8 ± 6.2	51.0 ± 10.4	55.0 ± 10.7	52.5 ± 10.5	<0.001
Total fat *(% E)*	35.3 ± 4.0	35.5 ± 6.9	34.7 ± 7.1	35.5 ± 6.9	0.259
Saturated Fat (g)	46.0 ± 8.6	46.5 ± 9.4	46.2 ± 8.4	45.2 ± 7.7	0.546
Monounsaturated Fat (g)	29.2 ± 6.5	28.6 ± 6.5	28.9 ± 6.2	30.1 ± 6.7	0.193
Polyunsaturated Fat (g)	16.5 ± 3.6	16.9 ± 4.0	15.8 ± 3.6	16.9 ± 3.2	0.052
Fiber (g)	36.2 ± 7.6	36.0 ± 8.1	37.6 ± 6.9	35.1 ± 7.6	0.067
Sugar (g)	145.6 ± 36.0	135.3 ± 38.0	159.6 ± 33.7	142.0 ± 31.8	<0.001
Micronutrient intake					
Cholesterol (mg)	364.6 ± 123.9	393.2 ± 128.2	342.8 ± 112.8	357.5 ± 125.7	0.011
Sodium (mg)	3141.7 ± 631.2	3236.5 ± 680.6	3020.6 ± 597.5	3167.7 ± 597.2	0.043
Vitamin A (IU)	2618.3 ± 1758.1	2555.4± 1816.3	2864.3 ± 1842.0	2432.2 ± 1590.5	0.197
Vitamin E (mg)	11.7 ± 2.7	12.0 ± 2.8	11.6 ± 2.8	11.4 ± 2.5	0.243
Vitamin C (mg)	247.4 ± 87.1	233.1 ± 85.6	276.4 ± 90.5	232.6 ± 78.0	<0.001
Iron (mg)	16.6 ± 2.3	16.2 ± 2.5	16.7 ± 2.0	16.9 ± 2.4	0.131
Calcium (mg)	755.7 ± 194.9	710.4 ± 225.0	814.0 ± 163.4	743.0 ± 177.2	<0.001
Potassium (mg)	4602.8 ± 811.2	4678.6 ± 851.1	4623.7 ± 752.6	4503.4 ± 824.7	0.292

*TEI,*Total energy intake; *kcal,one-unit* calorie; *E*, energy

*Values given are mean ± SD. All nutrient intakes adjusted for TEI based on child FFQ data.

† P-values for analysis of variance F-test (for TEI, amount of micro-and macro-nutrient intake) or generalized linear regression (for macronutrient intake as %E).

Table 3. Unadjusted associations between child nutritional status outcomes and study characteristics

Characteristics	N*	Stunting (HAZ< -2SD), n(%)	OW/OB (BMIZ> 2SD), n(%)	Anemia (Hb< 11.0 g/dL), n(%)
Total	305	62 (20.3)	49 (16.1)	104 (34.1)
Census Region				
Apia Urban Area	100	18 (18.0)	22 (22.0)	35 (35.0)
Northwest Upolu	102	18 (17.7)	12 (11.8)	32 (31.4)
Rest of Upolu	103	26 (25.2)	15 (14.6)	37 (35.9)
p†		0.313	0.124	0.769
Child				
24-35.99	122	41 (33.6)	23 (18.9)	52 (42.6)
36-47.99	103	21 (20.4)	17 (16.5)	40 (38.8)
48-59.99	80	0 (0.0)	9 (11.3)	12 (15.0)
p†		<0.001	0.351	<0.001
Gender: Female	148	23 (15.5)	23 (15.5)	53 (35.8)
Male	157	39 (24.8)	26 (16.6)	51 (32.5)
P		0.044	0.808	0.540
First Child	75	16 (21.3)	10 (13.3)	26 (34.7)
Not	230	46 (20.0)	39 (17.0)	78 (33.9)
p†		0.803	0.458	0.905
Reported birth weight[a]				
2500 g or less (Low)	7	1 (14.3)	0 (0.0)	2 (28.6)
2501-3999 g (Normal)	206	44 (21.4)	31 (15.1)	67 (32.5)
4000 g or more (Macrosomia)	69	11 (15.9)	14 (20.3)	23 (33.3)
p†		0.579	0.298	0.963
Ever Breastfed	208	36 (17.3)	32 (15.4)	69 (33.2)
Not	97	26 (26.8)	17(17.5)	35 (36.1)
p†		0.055	0.635	0.618
Reported illness in the past 3 weeks	29	5 (17.2)	5 (17.2)	14 (49.3)
No	276	57 (20.7)	44 (15.9)	90 (32.6)
p†		0.664	0.856	0.090
Deworming medication use in the past 3 weeks	59	14 (23.7)	12 (20.3)	26 (44.1)
No	243	48 (19.8)	37 (15.2)	77 (31.7)
p†		0.498	0.339	0.072
Eats daily breakfast in the past week	202	50 (24.8)	36 (17.8)	75 (37.1)
No	103	12 (11.7)	13 (12.6)	29 (28.2)
p†		0.007	0.242	0.118
Eats daily fruits	109	29 (26.6)	20 (18.4)	41 (37.6)
No	196	33 (16.8)	29 (14.8)	63 (32.1)
p†		0.042	0.418	0.334
Eats daily vegetables	138	35 (25.4)	24 (17.4)	51 (37.0)
No	167	27 (16.2)	25 (15.0)	53 (31.7)
p†		0.047	0.567	0.339
Drinks daily sweetened fruit juice	42	3 (7.1)	8 (19.1)	16 (38.1)
No	263	59 (22.4)	41 (15.6)	88 (33.5)
p†		0.022	0.571	0.556
Eats Weekly Frozen Desserts	234	35 (15.0)	35 (15.0)	73 (31.2)
No	71	27 (38.0)	14 (19.7)	31 (43.7)
p†		<0.001	0.339	0.052

HAZ, height-for-age z score; *OW/*OB, overweight and obesity; BMIZ*, body mass index(BMI)-for-age z score; Hb*, hemoglobin

*Numbers may not sum to totals due to missing data, and percentages may not sum to 100% due to rounding.

†P-value for Pearson χ^2 test.

[a] Twenty-three women did not know the birth weight their Child and were excluded.

Table 3 (continued) Unadjusted associations between child nutritional status outcomes and study characteristics

Characteristics	N*	Stunting (HAZ< -2SD), n(%)	OW/OB (BMIZ> 2SD), n(%)	Anemia (Hb< 11.0 g/dL) n(%)
Child				
Night time sleep (hours)				
8 or less	29	5 (17.2)	2 (6.9)	6 (20.7)
9-10	223	45 (20.2)	40 (17.9)	79 (35.4)
More than 10	47	11 (23.4)	7 (14.9)	17 (36.2)
p†		0.800	0.305	0.275
Total Screen time (minutes per day)				
Less than 60	54	13 (24.1)	7 (13.0)	17 (31.5)
60-119	171	34 (19.9)	30 (17.5)	59 (34.5)
120-179	58	12 (20.7)	6 (10.3)	20 (34.5)
180 or more	22	3 (13.6)	6 (27.3)	8 (36.4)
p†		0.777	0.249	0.972
Physical Activity Score				
Tertile 1 (mean: 24.1, SD:3.8)	109	26 (23.9)	20 (18.4)	34 (31.2)
Tertile 2 (mean: 29.1, SD: 0.7)	84	16 (19.1)	11 (13.1)	33 (39.3)
Tertile 3 (mean: 32.0, SD: 1.2)	112	20 (17.9)	18 (16.1)	37 (33.0)
p†		0.511	0.615	0.478
Mother				
Age (years)				
18-24.99	68	18 (26.5)	10 (14.7)	29 (42.7)
25-39.99	155	33 (21.3)	22 (14.2)	54 (34.8)
40+	82	11 (13.4)	17 (20.7)	21 (25.6)
p†		0.129	0.403	0.087
High school graduate	184	30 (16.3)	34 (18.5)	59 (32.1)
Not[a]	121	32 (26.5)	15 (12.4)	45 (37.2)
p†		0.031	0.157	0.356
Married or cohabitating	232	45 (19.4)	37 (16.0)	72 (31.0)
Not [b]	73	17 (23.3)	12 (16.4)	32 (43.8)
p†		0.471	0.921	0.044
OW/OB (BMI ≥26 kg/m^2)	266	50 (18.8)	45 (16.9)	89 (33.5)
No	39	12 (30.8)	4 (10.3)	15 (38.5)
p†		0.083	0.290	0.538
Any anemia	69	19 (27.5)	13 (18.8)	34 (49.3)
No	235	43 (18.3)	36 (15.3)	69 (29.4)
p†		0.094	0.484	0.002
Household				
Annual Income less than $10,000 tala	238	55 (23.1)	39(16.4)	84 (35.3)
$10,000 tala or more	66	7 (10.6)	10 (15.2)	20 (30.3)
p†		0.026	0.809	0.450
Material lifestyle Score, n(%)				
Quartile 1, (mean:1.3, SD:0.8)	63	12 (19.1)	5 (7.9)	22 (34.9)
Quartile 2, (mean:3.5, SD:0.5)	68	20 (29.4)	10 (14.7)	24 (35.3)
Quartile 3, (mean:5.9, SD:0.8)	97	18 (18.6)	14 (14.4)	31(32.0)
Quartile 4, (mean:10.5, SD:2.8)	77	12 (15.6)	20 (26.0)	27 (35.1)
p†		0.188	0.030	0.962
Community spirit				
Weak	7	3 (42.9)	1 (14.3)	2 (28.6)
Average	147	32 (21.8)	25 17.0)	53 (36.1)
Strong	150	27 (18.0)	23 (15.3)	49 (32.7)
p†		0.237	0.918	0.785[c]

HAZ, height-for-age z score; *OW/*OB, overweight and obesity; BMIZ*, body mass index(BMI)-for-age z score; Hb*, hemoglobin.

*Numbers may not sum to total due to missing data.

†P-value for χ^2 test.

[a] Mothers who report elementary school or less as highest education level.

[b] Mothers who report never married, separated, divorced, or widowed.

Table 4. Child dietary intake by nutritional status outcomes (N=305) *

	Stunting, (HAZ< -2SD), (n=62)	No Stunting (HAZ≥ -2SD), (n=243)	P†	OW/OB (BMIZ> 2SD), (n=49)	No OW/OB (BMIZ≤ 2SD), (n=256)	P†	Any Anemia (Hb< 11.0 g/dL), (n=104)	No Anemia (Hb≥ 11.0 g/dL), (n=201)	P†
TEI (kcal)	3396.6 ± 2386.9	3362.7 ± 2673.4	0.293	3342.3 ± 2343.8	3374.8 ± 2666.8	0.931	3413.8 ± 2667.6	3346.7 ± 2592.3	0.832
Intake as a percentage of energy (%E)									
Total protein	14.9 ± 7.5	14.3 ± 3.8	0.210	14.7 ± 8.5	14.4 ± 3.7	0.540	14.2 ± 5.8	14.6 ± 4.2	0.411
Total carbohydrates	52.3 ± 13.6	52.9 ± 6.9	0.446	51.5 ± 15.3	53.0 ± 6.7	0.108	53.2 ± 10.5	52.6 ± 7.6	0.382
Total fat	35.2 ± 8.8	35.3 ± 4.5	0.851	36.1 ± 9.9	35.0 ± 4.3	0.100	35.1 ± 6.8	35.4 ± 4.9	0.522
TEI-adjusted nutrient intake per day									
Saturated Fat (g)	46.5 ± 10.6	45.8 ± 8.0	0.639	48.0 ± 8.7	45.6 ± 8.5	0.066	46.3 ± 9.2	45.8 ± 8.2	0.577
Monounsaturated Fat (g)	28.8 ± 7.6	29.3 ± 6.1	0.627	29.8 ± 6.2	29.1 ± 6.5	0.439	28.4 ± 7.0	29.6 ± 6.1	0.118
Polyunsaturated Fat (g)	15.7 ± 4.3	16.7 ± 3.4	0.102	17.0 ± 3.9	16.4 ± 3.6	0.256	16.1 ± 3.8	16.7 ± 3.5	0.156
Fiber (g)	36.9 ± 7.6	36.1 ± 7.6	0.458	35.4 ± 6.7	36.4 ± 7.7	0.411	36.2 ± 7.6	36.3 ± 7.6	0.942
Sugar (g)	139.9 ± 39.3	147.1 ± 35.1	0.157	135.2 ± 31.1	147.6 ± 36.6	0.026	145.8 ± 35.6	145.5 ± 36.4	0.944
Cholesterol (mg)	368.8 ± 133.3	363.6 ± 121.6	0.768	391.7 ± 137.2	359.4 ± 120.7	0.095	362.1 ± 127.4	365.9 ± 122.3	0.801
Sodium (mg)	3193.7 ± 807.0	3128.4 ± 579.1	0.552	3255.2 ± 660.6	3120.0 ± 624.4	0.170	3093.0 ± 653.8	3166.9 ± 619.3	0.333
Vitamin A (IU)	3069.9 ± 2260.1	2503.0 ± 1590.5	0.067	2734.5 ± 1659.5	2596.0 ± 1778.6	0.614	2578.0 ± 1947.0	2639.1 ± 2578.0	0.774
Vitamin E (mg)	11.6 ± 2.7	11.7 ± 2.7	0.847	11.3 ± 2.5	11.7 ± 2.7	0.366	11.4 ± 2.9	11.8 ± 2.6	0.200
Vitamin C (mg)	270.7 ± 113.0	241.5 ± 78.3	0.058	238.2 ± 92.3	249.2 ± 86.1	0.412	250.0 ± 88.7	246.1 ± 86.4	0.709
Iron (mg)	16.6 ± 3.1	16.6 ± 2.1	0.910	17.3 ± 2.6	16.5 ± 2.3	0.027	16.9 ± 2.8	16.4 ± 2.0	0.131
Calcium (mg)	790.5 ± 276.2	746.8 ± 167.6	0.238	802.4 ± 194.7	746.8 ± 194.0	0.067	784.9 ± 236.7	740.6 ± 167.9	0.091
Potassium (mg)	4807.3 ± 796.9	4550.6 ± 808.2	0.026	4590.0 ± 696.3	4605.2 ± 832.6	0.904	4615.4 ± 898.1	4596.3 ± 764.7	0.846

kcal, one-unit calorie; OW*/OB,* overweight and obesity; *TEI,* Total energy intake.

* Mean± SD is given for each characteristic. Values based on data from FFQ.

† P-value for independent two-sided t-test (for TEI, amount of nutrient intake per day) or generalized linear regression (for macronutrient intake as percentage of energy).

Table 5. Multivariable logistic regression models of characteristics associated with child stunting, OW/OB, and anemia.

Characteristics	Stunting (N=305) Adjusted OR (95% CI)	Stunting P†	OW/OB (N=305) Adjusted OR (95% CI)	OW/OB P†	Anemia (N=304)[a] Adjusted OR (95% CI)	Anemia P†
Census Region						
Apia Urban Area	1.00	---	1.00	---	1.00	---
North West Upolu	0.74 (0.32, 1.75)	0.497	0.62 (0.26, 1.47)	0.277	0.80 (0.42, 1.54)	0.500
Rest of Upolu	1.22 (0.55, 2.71)	0.623	0.72 (0.33, 1.58)	0.414	1.04 (0.56, 1.95)	0.895
Child						
Age (months)						
24-35.99	1.00	---	1.00	---	1.00	---
36-47.99	0.56 (0.28, 1.11)	0.096	0.88 (0.43, 1.83)	0.739	0.88 (0.50, 1.54)	0.654
48-59.99	---	---	0.65 (0.27, 1.56)	0.334	0.25 (0.12, 0.53)	<0.001
Sex						
Male	1.00	---	1.00	---	1.00	---
Female	0.41 (0.21, 0.79)	0.006	0.89 (0.47, 1.70)	0.723	1.18 (0.71, 1.96)	0.531
TEI (kcal)	1.00 (1.00, 1.00)	0.485	1.00 (1.00, 1.00)	0.643	1.00 (1.00, 1.00)	0.383
Weekly Frozen Desserts	0.30 (0.14, 0.64)	<0.001				
Daily Breakfast	2.09 (0.93, 4.68)	0.073				
Vitamin C (10 mg/day)	1.04 (1.00, 1.07)	0.046				
Calcium (100 mg/day)			1.16 (1.00, 1.34)	0.056	1.14 (1.00, 1.30)	0.052
Sugar (10 g/day)			0.89 (0.80, 0.99)	0.032		
Mother and Household						
Material Lifestyle Score						
Quartile 1(mean: 1.3, SD: 0.8)			1.00	---		
Quartile 2(mean: 3.5, SD: 0.5)			1.75 (0.54, 5.70)	0.824		
Quartile 3(mean: 5.9, SD: 0.8)			1.98 (0.67, 5.89)	0.856		
Quartile 4(mean: 10.5, SD: 2.8)			3.61 (1.22, 10.71)	0.016		
Married					0.60 (0.34, 1.07)	0.084
Maternal Anemia					2.20 (1.22, 3.98)	0.007

OW*/OB,* overweight and obesity; *TEI,* Total energy intake; *kcal*, one-unit calorie.

† P-value for Likelihood Ratio χ^2 test.

[a]One participant was excluded due to a missing value for maternal anemia.