Title: Do Household Composition and Family Demographics Influence Nutritional Status among 3-7 year old Children in the Samoan Island of Upolu?

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Background/Motivation

Today Pacific Island countries face catastrophic levels of obesity(1). Adult obesity prevalence ranges from 6.8% in Papua New Guinea to 74.6% in American Samoa and Samoa has some of the poorest obesity outcomes among Pacific Island countries. Hawley et al. reported that 80.4% of men and 91.3% of women were overweight or obese in their 2010 study of Samoan adults (2). Our *Ola Tuputupua'e* "Growing Up" study in Samoa recently found that 28.9% of girls and 39.0% of boys were overweight or obese at age 5-7 years old (3). From a health and development perspective, high levels of obesity are particularly concerning among children because of the associated higher risks for cardiovascular disease, hypertension, and diabetes, and additional costs in economic productivity and health care later in adolescence and adulthood (4-7). Further attention in epidemiological research is needed to identify the modifiable risk and protective factors that can be targeted in childhood or earlier in life to reverse the trend in obesity.

Households remain central to many demographic, social, and economic processes that influence the health and well-being of children. Previous studies in other settings have described how child health is heavily influenced by the composition of households within the context of families (8-11). For example, the presence of one or more children in the household influences priorities with respect to the demand and allocation of resources for food, education, and health care. High dependency, indicated by a high number of children in the household, may deplete resources to the disadvantage of young children. There is a need to better understand the effects of household composition and family demographics on child health in Samoa to better guide interventions and policies to reduce the burden of obesity. As part of the nutrition and epidemiological transitions in Samoa over the recent decades, socioeconomic shifts in household income and occupation of family members are concomitant with changes in diet, increased sedentary behavior, and increased availability of imported, processed foods (12, 13). The primary research objective is to investigate the relationships and understand the pathways between children's nutritional status and a series of measures capturing the household composition and family demographics in the island of Upolu of Samoa.

Research Methods

Study design and data collection. This work consists of a cross-sectional analysis of data from the *Ola Tuputupua'e* "Growing Up" cohort study in Samoa. The overarching goal is to understand how lifestyle and environment contribute to risk of obesity and associated cardiometabolic diseases across the life course in Samoa. In partnership with Samoa Ministry of Health and Bureau of Statistics, the study was designed to follow 2-4 year old children and their biological mothers at two-year intervals into adulthood. We previously described the recruitment of the cohort, which took place between June and August 2015 in the Samoan island of Upolu (3). Briefly, a convenience sample of 319 mother–child pairs was recruited from 10 villages on the Samoan island of Upolu. Villages were selected to represent three census regions and differential exposure to the nutrition transition based on urbanicity: the Apia Urban Area (n=4 villages; urban area, high exposure), Northwest Upolu (n=3 villages; peri-urban with moderate exposure) and Rest of Upolu (n=3; rural with low exposure). Village leadership raised awareness among community members of the opportunity to participate in child health

research, and interested participants attended a central village location for eligibility screening and participation. Eligible children were Samoan (based on maternal report of having four Samoan grandparents) and within the 2–4.99-year age range. Eligible mothers were not pregnant and were willing and able to complete a questionnaire pertaining to their child's health. The second wave of data collection was completed between June and August in 2017 across 11 villages in Upolu. We used the same approach to village-based participant recruitment, and involved both follow-up of the original participants and an expansion of the cohort to n=420 mother-child pairs. The Yale University Institutional Review Board and the Health Research Committee of the Samoan Ministry of Health approved all procedures involving human subjects. Written informed consent was obtained from all participants in 2015 and 2017.

Study Sample. The sample consisted of Samoan children aged 3-7 years old at the time of the survey in 2017. For the present analyses, we excluded 62 children with missing data for any study variable. The final analysis sample included 358 children.

Assessment of Child Nutritional Status Outcomes. Overweight/obesity, stunting, and anemia status in 2017 were the main outcomes of interest. Duplicate measures of standing height and weight are assessed using standard epidemiologic methods: weight using calibrated scales with participants in light island clothing and height using calibrated stadiometers with the head in the Frankfort plane. A finger-prick blood hemoglobin sample was also taken using the AimStrip hemoglobin test system. We used the World Health Organization child growth standards and references to generate dichotomous outcome variables of nutritional status (14, 15). Overweight or obesity was defined as body mass index (BMI)-for age z-score above +2 SD for children under 5 and above +1 SD for children aged 5-7 years old. Any child whose height-for-age z-score was below -2 SD was classified as stunted. Child anemia was defined as having a hemoglobin level below 110 g/L for children under 5 and below 115 g/L for children aged 5-7 years (16).

Assessment of Exposures. Household composition was the main exposure of interest. We classified households according to (a) the number of individuals who usually reside in the household and (b) family socioeconomic status (SES). Mothers reported the number of dependent children and number of adults living in the household. To further classify households according to the relationships between usually resident people, we calculated a ratio of adults to children. Family SES was estimated using a 18-item material lifestyle score, which sums the ownership of durable consumable goods in the household(yes=1, no=0). This approach has been shown to be sensitive to SES in Samoa (17, 18). The material lifestyle score was further categorized into quartiles based on score distribution to distinguish low, medium, high, and very high family SES households.

Assessment of Covariates. Additional child, maternal, and household characteristics in 2017 were selected *a priori* for inclusion in regression models as potential confounders based on our prior experience in this setting. Dietary intake of children was assessed using a food frequency questionnaire (FFQ) with a thirty-day reference period. Mothers reported the intake frequency of food items across seven categories ranging from "never/less than once per month" to "more than six times per day". This FFQ was previously used in an adult study and adapted for the 2015 and 2017 follow-up. We calculated daily total energy intake and nutrients of children by multiplying the daily consumption frequency of each food by the nutrient content of a fixed, standard portion size. All nutrient intake data will be adjusted for total energy intake using the residual method (19). We also collected data on maternal demographics, including age, highest level of education attained, employment status, and marital status. For additional household characteristics, we estimated food insecurity in the past 6 months with an adapted version of the 16-item Escala Latinoamerican y Caribena de Seguidad Alimentaria (ELSCA) scale, which has been previously validated and used in other low- and middle-income settings (20). Households were categorized as either food secure (score=0), food insecure (1-5), very food insecure (5-10), or severely food insecure (score range: 11-16). Urbanicity of the household was approximated by the census region of the village where the child is surveyed. Households were categorized as rural in the Rest of Upolu region, peri-urban in the Northwest Upolu region, and urban in the Apia Urban Area region. Similar to the population and housing census survey in Samoa (21), mothers also reported the category of total annual income of the household as either " less than $2,499 tala", "$2,500-4,999 tala", "$5,000- $7,499 tala", "$7,500- $9,999 tala", "≤$10,000 tala", "$10,000 to $30,000 tala", "$30,001-$60,000", or ">$60,000 tala". We categorized annual household income as "less than $2,499 tala", "$2,500-$4,999 tala", "$5,000-$9,999 tala", "$10,000 tala or more" based on the response distribution.

Statistical Analyses. We first used descriptive statistics to examine the sample characteristics in 2017. Second, we examined differences in sample characteristics by family SES and child nutritional status outcomes among children at age 3-7 years old using generalized linear regression models for continuous variables, chi-squared tests for categorical variables, and total energy-adjusted generalized linear regression models for specific micronutrient intakes. A significance level of $\alpha=0.05$ was used and analyses were conducted with SAS version 9.4. (SAS Institute, North Carolina, USA). The analyses are on-going and we plan to continue with the following steps: First, multivariable logistic regression analyses will be performed to identify independent measures of household composition and family demographic correlates of child nutritional status outcomes. For each outcome, we will use a backward elimination strategy to determine the most parsimonious model. Variables significant at the 0.10 level will be retained in the final models, given the limited sample size. We will include census region, child's age, sex, and daily total energy intake in all models regardless of their statistical significance to ensure that observed associations were not confounded by these sample characteristics. For sensitivity analyses, we will perform additional multivariable analyses to explore whether the association between family demographics and household composition in relation to child nutritional status outcomes is mediated or confounded by child dietary intake and household food security score (Figure 1).

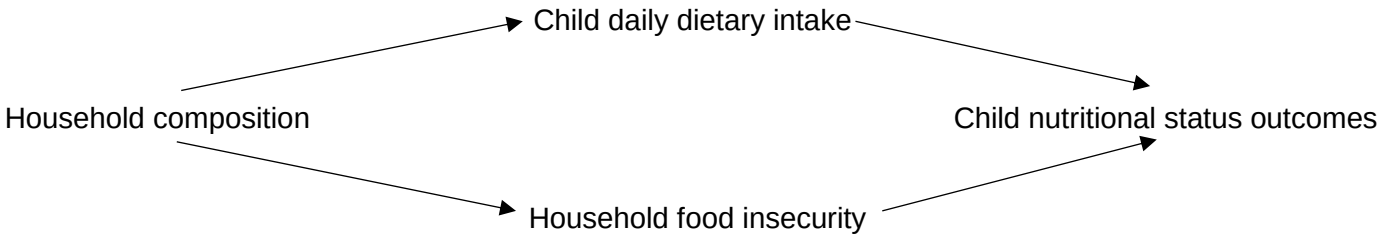

Figure 1. Simplified, schematic representation of potential pathways between household composition and child nutritional status outcomes

Preliminary Results

Table 1 presents the child, maternal, and household level characteristics of the sample in 2017. Among children at age 3-7 years old, the prevalence of overweight/obesity, stunting, and anemia was 28.3%, 7.2%, and 38.2%, respectively. The majority of children were female (51.40%, n=184), had a mother who completed high school (69.5%, n=249), was not employed (84.9%, n=304), and married or cohabitating (79.9%, n= 286), and lived in a food-secure household (51.1%, n=183). There were significant characteristic differences by family SES. On average, children living in very high family SES households had a higher daily intake of total fat, monounsaturated fat, and iron, but lower intake of fiber, cholesterol, calcium, Vitamin C, and potassium compared to those in the low family SES households. The average number of dependent children was lowest in the very high family SES households compared to the other households, while the number of adults was highest in the high and very high family SES households

Table 2 presents the unadjusted associations between child nutritional status outcomes in relation to family demographics and household composition in 2017. Overweight/obesity at age 3-7 years old was negatively associated with the number of dependent children living in the same household (p=0.088). Households with overweight/obese children had less dependent children (4.13 ± 2.58) compared to those who were not (4.64 ± 2.28). On average, children classified with stunting lived in a household with one more dependent child (5.58 ± 2.80) compared to those without stunting (4.45 ± 2.30) and this was statistically significant (p=0.022). Family SES was not significantly associated with any child nutritional status outcome.

The results should be interpreted in the context of the study limitations. We used cross sectional data and thus, we are unable to tease apart temporality and cannot make causal inferences. Our characterization of the household composition and family context is limited given that the question did not collect in-depth information on family dynamics, quality of familial interaction, and/or family caregiving. For future, follow-up assessments in the *Ola Tuputupua'e* study, we hope to collect these data to examine broader dimension of child health and family relationships. The relationship between household composition, family demographics, and nutritional status is complex and as such, there are potential confounders not controlled for in the study.

Expected Results/Implications

Logistic regression models will provide an estimate for the unadjusted and adjusted odds ratio of overweight or obesity, stunting, and anemia at age 3-7 years old among children. We will also identify which measures of

household composition and family demographic are independently correlated with nutritional status in these models after adjusting for potential confounders and exploring potential mediators such as child dietary intake. The findings will help us to uncover potential pathways for the development of obesity, stunting, and anemia and may suggest household-level targets for preventative interventions in Samoa. Moreover, understanding the effects of household composition and family demographics on child health outcomes in this setting over time will be relevant for efforts to achieve Sustainable Development Goal 1 (end poverty in all its forms everywhere), as well as Goal 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and Goal 3 (ensure healthy lives and promote well-being for all at all ages).

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Table 1. Sample description by family socioeconomic status: Samoa, 2017

Characteristics	Total	Family socioeconomic status*, mean ± SD or n (%)				P†
		Low	Medium	High	Very high	
Child, n	358	89	72	95	102	
Age (years)	5.31 ± 0.94	5.24 ± 0.92	5.32 ± 0.86	5.33 ± 1.01	5.36 ± 0.96	0.844
Female	184 (51.40)	45 (50.56)	42 (58.33)	40 (42.11)	57 (55.88)	0.138
Daily dietary intake						
Total energy (kcal)	4606.14 ± 5311.16	3972.79 ± 4101.69	3955.14 ± 3602.08	4871.22 ± 6053.25	5371.40 ± 6364.90	0.195
Total protein (g)	138.92 ± 25.69	141.62 ± 27.10	138.81 ± 31.64	137.83 ± 22.33	137.67 ± 22.70	0.708
Total carbohydrate (g)	524.30 ± 52.92	528.95 ± 59.68	528.13 ± 48.59	525.39 ± 48.84	516.54 ± 53.15	0.349
Total fat (g)	152.01 ± 19.70	149.77 ± 21.82	148.51 ± 17.88	152.22 ± 19.02	156.24 ± 19.10	0.043
Saturated fat (g)	48.12 ± 10.33	59.37 ± 10.20	59.75 ± 8.35	60.47 ± 8.71	61.70 ± 9.02	0.312
Monounsaturated fat (g)	24.03 ± 4.45	47.44 ± 10.78	45.88 ± 8.84	47.76 ± 10.04	50.64 ± 10.81	0.018
Polyunsaturated fat (g)	60.40 ± 9.13	23.58 ± 4.92	23.16 ± 4.78	24.40 ± 4.14	24.70 ± 3.97	0.084
Fiber (g)	51.21 ± 8.93	53.15 ± 9.93	51.58 ± 8.91	51.63 ± 7.27	48.88 ± 9.06	0.009
Sugar (g)	206.08 ± 38.10	201.53 ± 36.90	209.17 ± 40.08	209.18 ± 38.18	204.98 ± 37.74	0.485
Cholesterol (mg)	433.50 ± 123.07	407.13 ± 135.50	417.33 ± 110.68	435.18 ± 100.05	466.35 ± 133.11	0.005
Sodium (mg)	4522.56 ± 835.29	4515.97 ± 1015.14	4434.06 ± 720.34	4496.28 ± 723.41	4615.24 ± 837.57	0.541
Calcium (mg)	1067.81 ± 193.50	1111.00 ± 217.16	1103.49 ± 239.45	1061.85 ± 155.73	1010.50 ± 149.92	0.001
Vitamin A (IU)	2340.29 ± 1100.85	2439.92 ± 1065.73	2205.85 ± 955.38	2416.98 ± 997.20	2276.83 ± 1302.15	0.459
Vitamin C (mg)	357.24 ± 122.53	379.60 ± 137.34	358.03 ± 118.75	365.32 ± 118.14	329.63 ± 111.63	0.035
Vitamin E (mg)	17.48 ± 3.83	18.17 ± 3.76	17.04 ± 4.05	17.61 ± 3.27	17.07 ± 4.16	0.166
Iron (mg)	24.76 ± 2.56	24.51 ± 2.59	24.12 ± 2.21	25.09 ± 2.67	25.12 ± 2.58	0.029
Potassium (mg)	6147.64 ± 1173.48	6485.99 ± 1386.79	6154.41 ± 1092.13	6189.37 ± 982.54	5808.77 ± 1111.89	0.001
Maternal						
Age (years)	34.98 ± 8.79	35.28 ± 8.67	34.94 ± 9.38	34.39 ± 8.59	35.30 ± 8.75	0.881
Education: Less than high school	26 (7.26)	13 (14.61)	7 (9.72)	4 (4.21)	2 (1.96)	
High school completed	249 (69.55)	64 (71.91)	54 (75.00)	68 (71.58)	63 (61.76)	
College/University completed	83 (23.18)	12 (13.48)	11 (15.28)	23 (24.21)	37 (36.27)	
Not employed‡	304 (84.92)	80 (89.89)	65 (90.28)	80 (84.21)	79 (77.45)	0.050
Married/cohabitating§	286 (79.89)	76 (85.39)	61 (84.72)	73 (76.84)	76 (74.51)	0.164
Household						
Number of children	4.53 ± 2.35	4.57 ± 2.30	4.61 ± 2.15	5.11 ± 2.64	3.88 ± 2.11	0.003
Number of adults	3.93 ± 2.66	2.90 ± 1.64	3.99 ± 2.32	4.84 ± 3.35	3.94 ± 2.60	<0.001
Adults:children	1.15 ± 1.16	0.85 ± 0.79	1.17 ± 1.37	1.12 ± 0.87	1.44 ± 1.42	0.006
Census Region: Rest of Upolu	116 (32.40)	36 (40.45)	29 (40.28)	29 (30.53)	22 (21.57)	
Northwest Upolu	119 (33.24)	32 (35.96)	19 (26.39)	38 (40.00)	30 (29.41)	
Apia Urban Area	123 (34.36)	21 (23.60)	24 (33.33)	28 (29.47)	50 (49.02)	
Food Security						0.106
Secure (mean:0, SD:0)	183 (51.12)	38 (42.70)	34 (47.22)	46 (48.42)	65 (63.73)	
Low (mean:2.33, SD:1.03)	98 (27.37)	27 (30.34)	21 (29.17)	31 (32.63)	19 (18.63)	
Very Low (mean:7.61, SD:1.44)	44 (12.29)	11 (12.36)	9 (12.50)	11 (11.58)	13 (12.75)	
Extremely low (mean:14.68, SD:0.73)	33 (9.22)	13 (14.61)	8 (11.11)	7 (7.37)	5 (4.90)	
Annual household income						<0.001
Less than $2,499	149 (41.62)	49 (55.06)	34 (47.22)	39 (41.05)	27 (26.47)	
$2,500-4,999	58 (16.20)	11 (12.36)	13 (18.06)	13 (13.68)	21 (20.59)	
$5,000-9,999	84 (23.46)	23 (25.84)	17 (23.61)	24 (25.26)	20 (19.61)	
More than $10,000	67 (18.72)	6 (6.74)	8 (11.11)	19 (20.00)	34 (33.33)	

* Quartiles were generated based on the distribution of the material lifestyle score, which is the sum of 18 consumer durables owned (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).
† P-value for Chi-squared or Fisher's exact test (for categorical variables) and generalized linear regression (for continuous variables).
‡ Compared to mothers who worked full time, part time, or as a student.
§ Compared to mothers who were separated, widowed, or unmarried.

Table 2. Unadjusted associations between nutritional status at age 3-7 years old in relation to family demographics and household composition: Samoa, 2017

	Nutritional Status Outcomes, mean ± SD or n (%)								
Characteristics	Overweight/ Obesity	Not	P*	Stunting	Not	P*	Anemia	Not	P*
Child, n	79	279		24	334		99	259	
Age (years)	5.82 ± 0.75	5.17 ± 0.94	<0.001	4.95 ± 0.92	5.34 ± 0.94	0.047	5.45 ± 0.85	5.26 ± 0.97	0.083
Female	37 (46.84)	147 (52.49)	0.358	14 (58.33)	170 (50.90)	0.482	45 (45.45)	139 (53.67)	0.164
Maternal									
Age (years)									
Education: Less than high school	4 (5.06)	22 (7.89)	0.148	1 (4.17)	25 (7.49)	0.137	9 (9.09)	17 (6.56)	0.705
High school completed	62 (78.48)	187 (67.03)		21 (87.50)	228 (68.26)		68 (68.69)	181 (69.88)	
College/University completed	13 (16.46)	70 (25.09)		2 (8.33)	81 (24.25)		22 (22.22)	61 (23.55)	
Not employed†	66 (83.54)	238 (85.30)	0.723	23 (95.83)	281 (84.13)	0.148	85 (85.86)	219 (84.56)	0.758
Married/cohabitating‡	65 (82.28)	221 (79.21)	0.548	22 (91.67)	264 (79.04)	0.188	80 (80.81)	206 (79.54)	0.788
Household									
Number of children	4.13 ± 2.58	4.64 ± 2.28	0.088	5.58 ± 2.80	4.45 ± 2.30	0.022	4.72 ± 2.33	4.45 ± 2.36	0.341
Number of adults	3.92 ± 2.90	3.93 ± 2.60	0.982	3.33 ± 2.50	3.97 ± 2.67	0.256	3.61 ± 2.18	4.05 ± 2.82	0.155
Adults:children	1.30 ± 1.15	1.11 ± 1.16	0.214	0.65 ± 0.43	1.19 ± 1.19	0.029	1.03 ± 1.01	1.20 ± 1.21	0.209
Census region: Rest of Upolu	19 (24.05)	97 (34.77)		9 (37.50)	114 (34.13)		35 (35.35)	88 (33.98)	
Northwest Upolu	27 (34.18)	92 (32.97)		8 (33.33)	111 (33.23)		32 (32.32)	87 (33.59)	
Apia Urban Area	33 (41.77)	90 (32.26)		7 (29.17)	109 (32.63)		32 (32.32)	848 (32.43)	
Food Security			0.573			0.788			0.510
Secure (mean:0, SD:0)	40 (50.63)	143 (51.25)		12 (50.00)	171 (51.20)		53 (53.54)	130 (50.19)	
Low (mean:2.33, SD:1.03)	18 (22.78)	80 (28.67)		5 (20.83)	93 (27.84)		29 (29.29)	69 (26.64)	
Very Low (mean:7.61, SD:1.44)	12 (15.19)	32 (11.47)		5 (20.83)	39 (11.68)		8 (8.08)	36 (13.90)	
Extremely low (mean:14.68, SD:0.73)	9 (11.39)	24 (8.60)		2 (8.33)	31 (9.28)		9 (9.09)	24 (9.27)	
Annual household income			0.276			0.555			0.660
Less than $2,499	116 (41.58)	33 (41.77)		136 (40.72)	13 (54.17)		37 (37.37)	112 (43.24)	
$2,500-4,999	50 (17.92)	8 (10.13)		54 (16.17)	4 (16.67)		15 (15.15)	43 (16.60)	
$5,000-9,999	65 (23.30)	19 (24.05)		80 (23.95)	4 (16.67)		26 (26.26)	58 (22.39)	
More than $10,000	48 (17.20)	19 (24.05)		64 (19.16)	3 (12.50)		21 (21.21)	46 (17.16)	
Family socioeconomic status§			0.303			0.318			0.087
Low (mean=1.15, SD=0.85)	19 (24.05)	70 (25.09)		6 (25.00)	83 (24.85)		32 (32.32)	57 (22.01)	
Medium (mean=3.47, SD=0.50)	13 (16.46)	59 (21.15)		8 (33.33)	64 (19.16)		23 (23.23)	49 (18.92)	
High (mean=5.96, SD=0.82)	18 (22.78)	77 (27.60)		6 (25.00)	89 (26.65)		22 (22.22)	73 (28.19)	
Very high (mean=10.91, SD=2.67)	29 (36.71)	73 (26.16)		4 (16.67)	98 (29.34)		22 (22.22)	80 (30.89)	

* P-value for Chi-squared or Fisher's exact test (for categorical variables) and generalized linear regression (for continuous variables).

† Compared to mothers who worked full time, part time, or as a student.

‡ Compared to mothers who were separated, widowed, or unmarried.

§ Quartiles were generated based on the distribution of the material lifestyle score, which is the sum of 18 consumer durables owned (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).