Social Predictors of Diet Quality in Galapagos, Ecuador

By
Elijah Watson

Senior Honors Thesis
Department of Anthropology
University of North Carolina at Chapel Hill

2019

Approved:

Amanda L. Thompson

Amanda Thompson, Thesis Advisor

Mark Sorensen, Reader

Margaret Bentley, Reader

ACKNOWLEDGEMENTS

First, I would like to thank Dr. Amanda Thompson for her guidance and support throughout my summer research internship and honors thesis. I also want to thank Dr. Margaret Bentley and Dr. Mark Sorensen for serving on my committee and providing their feedback on my work. I also would like to Chelsea Philyaw and my family for their unending support throughout the entire process.

Direct support for my summer research internship at CPC was provided by the Office of the Vice Chancellor for Research at the University of North Carolina at Chapel Hill. The CPC summer undergraduate internship program also received support from the Population Research Infrastructure Program awarded to the Carolina Population Center (P2C HD050924) at The University of North Carolina at Chapel Hill by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD). Additionally, this research was supported by the Honors Carolina Gillian T. Cell Senior Thesis Fund.

Table of Contents

List of Abbreviations

OWT/NCD (Overweight and non-communicable disease)

UW/ID (Underweight and infectious disease)

ENSANUT-ECU (National Health and Nutrition Survey-Ecuador)

DQI-I (Diet Quality Index-International)

RDA (Recommended Daily Amount)

Introduction

Located roughly 600 miles off of the coast of Ecuador, Galapagos is best known for its biodiversity. The archipelago consists of fourteen volcanic islands, four of which are currently home to a total of 25,244 residents (INEC, 2015). Ninety-seven percent of the geographic area of the Galapagos is a designated national park, with only a small and increasingly populated area available for human habitation (Parque Galapagos, 2011). The population of the islands has increased by more than 300% in recent decades (Larrea, 2008). Additionally, tourism and migration have fueled rapid economic, environmental, and demographic change in the Galápagos Islands, resulting in new pressures on human health and changing food systems (Walsh et al., 2010; Walsh & Mena, 2013). However, outdated water and sanitation systems along with inadequate water quantity have led to poor water quality with residents often resorting to imported water and external cistern storage. Furthermore, residents primarily rely on food shipped from mainland Ecuador, much of which is processed and can contribute to poor health (Walsh et al., 2010; Walsh & Mena, 2013).

The economic development and social changes being experienced in low- and middle-income countries, such as Ecuador, are often associated with an increase in the prevalence of overweight, obesity, and noncommunicable diseases (OWT/NCD) (Popkin, Adair & Ng, 2012). However, under-nutrition and infectious diseases (ID/UND) continue to exist due to considerable geographic, socioeconomic and demographic variability in these changes. Economic- and development-associated changes in diet outpace changes in infrastructure for food, water, and sanitation systems. Therefore, individuals can be exposed both to high-fat, energy-dense diets and to pathogens associated with poor water quality and inadequate sanitation. These factors converge to create a dual burden of OWT/NCD and UND/ID.

Research has shown that the dual burden not only varies across in populations (Griffiths & Bentley, 2001), but also within households and individuals (Doak et al. 2000; Doak et al., 2005). For example, within a household, a parent may be overweight while their child is stunted. An individual may be both overweight due to an unhealthy diet and stunted due to micronutrient deficiencies. Cross-national comparisons suggest that greater household income and urbanization contribute to the dual burden of nutritional disease in middle-income countries (Tzioumis & Adair, 2014; Doak et. al 2005). Studies have shown an increasing co-occurrence of overweight mothers and stunted children in lower income, rural indigenous households in Guatemala and Mexico (Fernald & Neufeld, 2007; Lee et al., 2010). Within Ecuador, Galapagos has the highest rates of obesity in all age groups amongst all provinces, while levels of stunting, (11% in children younger than five) and micronutrient deficiencies of iron (16% in children younger than five) and zinc (57% of reproductive age women) are common (Freire et al., 2013; Freire et al., 2015).

These findings highlight the pressing need to study the social patterning of this dual burden in Galapagos and other low- and middle-income countries. However, the effects of poor water and diet quality exposures and the underlying social determinants of poor health are difficult to distinguish. Demographic and socioeconomic factors have been shown to be associated with differences in diet quality (Darmon & Drewnowski, 2015; Alkerwi et al., 2015; Chong, Appannah, & Sulaiman, 2019). Composite indices are preferred in nutritional epidemiology over those that are based on a specific nutrient or food group because of the varying factors that contribute to diet quality (Gerber, 2001 & Kant, 1996). The Diet Quality Index-International (DQI-I) was chosen to assess diet quality in this study because it was created in order to be used in settings experiencing a nutritional transition to higher prevalences of obesity and metabolic diseases (Kim, Haines, Siega-Riz, & Popkin, 2002). The DQI-I takes into account dietary variety, adequacy, moderation, and balance in order to provide a nuanced understanding of factors contributing to overall diet quality.

This study specifically focuses on the social predictors of diet quality and dietary adequacy in Galapagos. Additionally, the social predictors of adequate intake of calcium and iron are examined in respondents ages 18 or younger. Adequate intake of iron has been linked to healthy cognitive development in children in the nutritional epidemiology literature, while poor intake of calcium has been linked with stunting (Lozoff 1988; Pollitt 1993; Stuijvenberg et al., 2015). The few studies on human health in Galapagos indicate that obesity and overweight are amongst the most pressing public health challenges facing the islands (for example, Friere 2018; Page, Bentley & Waldrop 2013). The unique challenges that Galapagos faces will change as the islands continue to grow and change, creating new pressures on human health and food systems and exacerbating existing inequalities. The findings from this study can provide evidence for future research on the social patterning of the dual burden in Galapagos that examines how social factors mediate the relationship between the dual burden and food and water exposures.

Research Questions & Study Aims

This study uses quantitative methods to address the following research question:

- What are the socioeconomic predictors of overall diet quality and dietary adequacy in Galapagos, Ecuador?

  Understanding the social determinants of diet quality and dietary adequacy is important for informing interventions and policy responses in Galapagos that aim to improve diet quality and nutritional health. It is hypothesized that rural household location, food insecurity, and lower socioeconomic status will predict lower diet quality and adequacy.

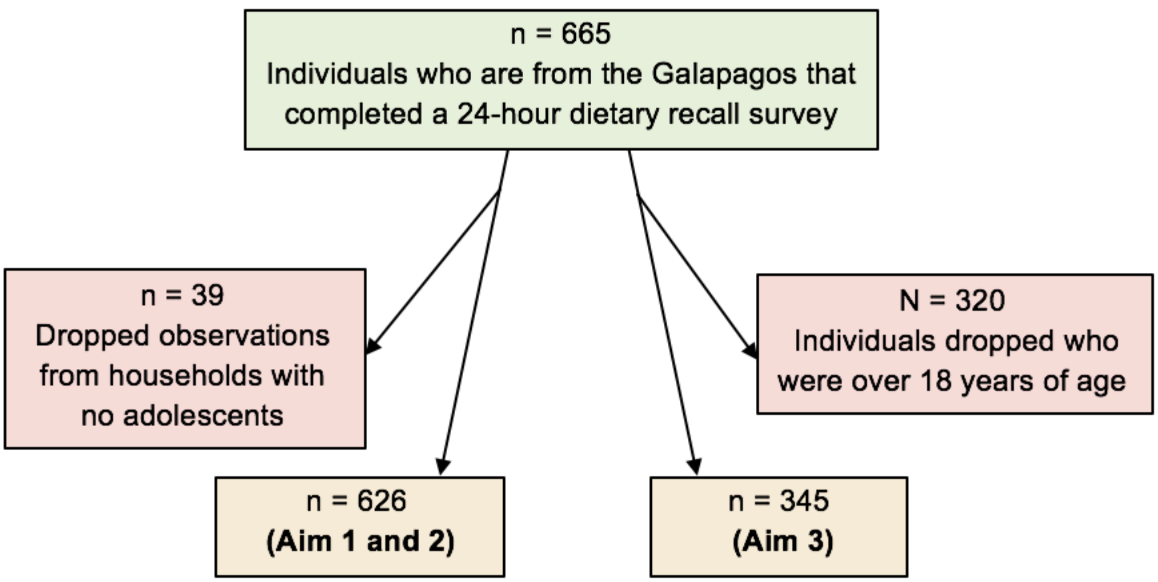
To address these research questions, this study investigates the following four aims:

Aim 1	Describe the socioeconomic factors and dietary characteristics of the overall sample.
Aim 2	Examine the socioeconomic predictors of diet quality and adequacy in the overall sample.
Aim 3	Examine the socioeconomic predictors of adequate intake of iron and calcium in children under 18 years of age.

Methods

<u>Sample</u>

Data came from the nationally-representative *Encuesta Nacional de Salud y Nutrición* (ENSANUT-ECU) 2012 (Freire et al., 2013). 665 respondents in the Galapagos completed a 24-hour dietary recall survey, a method that is described below. For Aim 1 and 2, the sample (n=626) only included individuals coming from households with at least one individual under 18 years of age. For aim 3, the sub-sample (n=345) included only individuals ages 18 or younger. In this study, children are defined as individuals 18 years of age or younger.



<u>Variables and Measures</u>

24-hour dietary recall data

ENSANUT-ECU 2012 used single 24-hour dietary recalls to gather data on diet behaviors. 24-hour recalls involve an individual recalling every item of food that they ate during the past day, which is also measured in "serving" or "plate" sizes by the interviewer. 24-hour recalls are commonly used in nutrition research, yet there is unavoidable participant recall bias due to the likelihood that not everyone will remember every single item of food and the amount that they ate during the past day (Ma et al. 2009). However, directly observing every individual's eating behaviors for 24-hours would be expensive and extremely time-intensive. Therefore, 24-hour recalls are often considered the best tool to assess diet quality in a population (Hébert 2014).

Diet Quality Index

The Diet Quality Index-International (DQI-I) is a tool developed "for exploring aspects of diet quality related to the nutrition transition (Kim et al. 2003)". Kim et al. (2003) adapted the index from the original Diet Quality Index (Patterson et al. 1994). Dietary quality in this index is composed of adequacy, moderation, and overall balance (see Appendix 1 for detailed scoring breakdown). Achieving more dietary variety and adequacy results in a higher score, as does having a well-moderated and more-balanced diet. Kim et al. (2003) developed the index and demonstrated its effectiveness in comparing diet quality cross-nationally between China and the United States. Mariscal-Arcas et al. (2007) adapted the index to Mediterranean context to assess diet quality among young people in Southern Spain

The variety sub-component is based on the variety according to five major food groups (meat/poultry/fish/eggs; dairy/beans; grain; fruit; vegetable) as well as within protein-group variety (meat, poultry, fish, dairy, beans, eggs). The adequacy component assesses servings of fruits, vegetables and grains, in addition to adequate intakes of fiber, protein, iron, calcium and vitamin C relative to Dietary Reference Intakes and Daily Recommended Amounts, which may vary by age and gender. Adequacy of protein is scored based on the percentage of energy provided by protein, with greater than 10% being the highest attainable score. Adequacy sub-component scores for iron, calcium and vitamin C are based on the respective recommended daily allowances, reference nutrient intakes, and adequate intake amounts. Moderation of fat, saturated fat, sodium, cholesterol, and empty-calorie foods contributed to the moderation component score. The concept of nutrient density, the ratio of nutrients to energy in a certain amount of food compared with the recommended intake levels, was used to assess the percentage of total energy provided from low-nutrient dense or "empty-calorie foods." The overall balance component consisted of the ratios of macronutrients and fatty acids. Data on empty calorie foods were not available; therefore, for this analysis 94 points was the maximum score possible rather than 100.

Socioeconomic Variables

The sample was distributed across the islands of San Cristobal (the capital city of Puerto Baquerizo Moreno and the rural town of El Progreso) and Santa Cruz (the urban town of Puerto Ayora and the rural towns of Santa Rosa and Bellavista). Sociodemographic variables included both head of household- and individual-level factors. Individual-level characteristics included sex, age, and self-identified ethnicity (mestizo, indigenous, white, and other). Head of household variables included migration status (from Galapagos or from elsewhere), education level (primary or below, secondary, or post-secondary), marital status (married/partnered or not married/not partnered). Household-level characteristics included a household wealth index, household size, and household food security.

<u>Statistical Analyses</u>

Statistical analyses were conducted using Stata v. 15.1 (StataCorp, College Station, TX, USA). To achieve Aim 1, descriptive statistics were used to describe that socioeconomic factors and diet characteristics of the respondents. Chi-square analyses were used to test for differences between socioeconomic factors and dietary variety. Because of the large percentage of maximum variety scores, for these analyses variety was dichotomized into having either the highest score or any score less than the highest.

To achieve Aim 2, separate multiple linear regression models were used to identify socioeconomic predictors of DQI-I and adequacy sub-component scores in the overall sample. Simple linear regression was used to identify variables for inclusion in the multiple linear regression models. All of the socioeconomic variables except household wealth index were included in the models for Aim 2. An interaction term was included between island and urban/rural to control for inter-island differences. Outliers were removed in order to achieve normality of residuals. Nine outlier DQI-I scores were removed, resulting in 617 observations for DQI-I model. From these 617 observations, 9 outlier adequacy sub-component scores were dropped, resulting in 608 observations for the adequacy model. The results changed minimally after removal of outliers.

To achieve Aim 3, separate multiple linear regression models were used to identify predictors of adequate intake of iron and calcium in respondents ages 18 or younger (n=345). The iron and calcium adequacy sub-component scores are a scaled representation of the percentage of RDA achieved for each nutrient. For easier interpretability, percentage of RDA achieved was used as the predictor variable instead of the scaled DQI-I sub-component scores. Simple linear regression was used to identify variables for inclusion in the multiple linear regression models. The model for iron included all socioeconomic variables except household size, household wealth index, and head of household marital status. The model for calcium included all socioeconomic variables except household wealth index, sex, and age category. Five outlier calcium adequacy scores were dropped in order to achieve normality of residuals for the calcium model. Due to the presence of heteroscedasticity, robust standard errors were used for both models in Aim 3.

Results

Sample characteristics: Socioeconomic factors

Table 2 shows the socioeconomic characteristics of the overall sample (n=626). The majority of respondents in the sample resided in urban areas and on the island of Santa Cruz. 55% of respondents were 18 or younger, while 45% of respondents were older than 18. The age range of respondents was 1-59 years. Approximately 60% of respondents were female and approximately 86% were of *Mestizo* ethnicity, with smaller numbers of Indigenous, White, and Afro-Ecuadorian individuals. Approximately 23% of households were food insecure. 60% of households were in the two highest wealth quintiles. Household sizes ranged from two to ten and 79% of households had five or fewer members. Approximately 85% of heads of households in the sample migrated from elsewhere to the Galapagos Islands, 50% had achieved secondary-level education, and 64% were married or partnered.

Chi-square analyses revealed significant differences between islands in regards to sex, race (self-identifying as Mestizo versus non-Mestizo), household wealth index, household size, and head of household location of origin. 63% of respondents in Santa Cruz were women, while the amounts of women and men in San Cristobal were almost equal. Approximately 84% of respondents in Santa Cruz and 90% in San Cristobal self-identified as Mestizo. Approximately 25% of respondents in Santa Cruz and 15% in San Cristobal were in the lowest two wealth index quintiles.

Table 1. Sample characteristics (n = 626)

Socioeconomic Variables	Overall Sample n (column %)	Santa Cruz n (column %)	San Cristobal n (column %)
Geographic Area			
Urban	486 (77.64)	292 (75.25)	194 (78.23)
Rural	140 (22.36)	86 (22.75)	54 (21.77)
Island			
Santa Cruz	378 (60.38)	378 (100.00)	–
San Cristobal	248 (39.62)	–	248 (100.00)
Age Category			
Less than 5	79 (12.62)	50 (13.23)	29 (11.69)
5 – 12	175 (27.96)	103 (27.25)	72 (29.03)
12 –18	91(14.54)	53 (14.02)	38 (15.32)
Older than 18	281 (44.89)	172 (45.50)	109 (45.95)
Sex			
Male	378 (60.38)	139 (36.77)	121 (48.79)**
Female	248 (39.62)	239 (63.23)	127 (51.21)
Race			
Mestizo	539 (86.10)	316 (83.60)	223 (89.92)**
Indigenous	52 (8.31)	42 (11.11)	10 (4.03)
White	12 (1.92)	5 (1.32)	7 (2.82)
Other	23 (3.67)	15 (3.97	8 (3.23)
Household Food Security			
Food Secure	443 (70.77)	276 (73.02)	167 (67.34)
Food Insecure	183 (23.23)	102 (26.98)	81 (32.66)
Household Wealth Index			
1st Quintile	59 (9.42)	43 (11.38)	16 (6.45)***
2nd Quintile	71 (11.34)	50 (13.23)	21 (8.47)
3rd Quintile	114 (18.21)	65 (17.20)	49 (19.76)
4th Quintile	209 (33.39)	146 (38.62)	63 (25.40)
5th Quintile	173 (27.64)	74 (19.58)	99 (39.92)
Household Size			
5 members or less	493 (78.75)	319 (84.39)	174 (70.16)***
More than 5 members	133 (21.25)	59 (15.61)	74 (29.84)
Head of HH Origin			
Migrant to Galapagos	531 (84.82)	351 (92.86)	180 (72.58)***
Native to Galapagos	95 (15.18)	27 (7.14)	68 (27.42)
Head of HH Education Level			
Primary or below	196 (31.31)	117 (30.95)	79 (31.85)
Secondary	313 (50.00)	200 (52.91)	113 (45.56)
Post-Secondary	117 (18.69)	61 (16.14)	56 (22.58)
Head of HH Marital Status			
Married or Partnered	402 (64.22)	240 (63.49)	162 (65.32)
Not Married or Partnered	35.78 (35.78)	138 (36.51)	86 (34.68)

*** p<0.001, ** p<0.01, * p<0.05 denotes chi-square test significance
Race was categorized as Mestizo and non-Mestizo for the analyses in this study

Sample Characteristics: DQI-I and Variety Subcomponent Scores

Table 2 (below) contains the mean total DQI-I and sub-component scores for the overall sample. The mean total DQI-I score was 63.1 ± 7.11 out of a maximum of 94. The mean variety score was 18.71 ± 2.46 out of 20. The mean adequacy score was 28.95 ± 4.05 out of 40. Mean adequacy sub-scores for were highest for fruit, protein, and vitamin C and lowest for iron, fiber, and calcium. The mean moderation score was 13.31 ± 3.92 out of 24. While mean sub-scores for sodium and cholesterol moderation were high, mean sub-scores for moderation of total fat and saturated fat were 2.27 ± 1.56 and 0.71 ± 1.42 out of 6, respectively. The mean score for balance was 2.12 ± 2.42 out of 10.

Table 2. Mean DQI-I component scores

DQI-I Component	Score (Mean ± SD)	Max Possible Score
Total DQI-I Score	*63.1 ± 7.11*	*94**
Variety Component	*18.71 ± 2.46*	*20*
Overall food group variety	14.07 ± 1.66	15
Within-group variety for protein	4.65 ± 1.13	5
Adequacy Component	*28.95 ± 4.05*	*40*
Vegetable group	4.76 ± 0.92	5
Fruit group	3.83 ± 1.74	5
Grain group	3.03 ± 1.12	5
Fiber	2.47 ± 0.89	5
Protein	4.99 ± 0.09	5
Iron	2.97 ± 1.29	5
Calcium	2.34 ± 0.93	5
Vitamin C	4.57 ± 0.82	5
Moderation Component	*13.31 ± 3.92*	*24*
Total fat	2.27 ± 1.56	6
Saturated fat	0.71 ± 1.42	6
Cholesterol	4.45 ± 2.36	6
Sodium	5.88 ± 0.75	6
Empty calorie foods*	–	–
Balance Component	*2.12 ± 2.42*	*10*
Macronutrient ratio	0.58 ± 1.77	6
Fatty acid ratio	1.54 ± 1.63	4

*The max possible score is 94 because data on empty calorie foods was not available

Table 2. Socioeconomic factors and dietary variety

Socioeconomic Variables	**Variety Score of less than 20** n (row %)	**Variety Score of 20 / 20** n (row %)	**Total** n (row %)
n	170 (27.16)	456 (72.16)	626 (100)
Geographic Area**			
Urban	116 (23.87)	370 (76.13)	486 (100)
Rural	54 (38.57)	86 (61.43)	140 (100)
Household Food Security**			
Food Secure	108 (23.38)	335 (75.62)	443 (100)
Food Insecure	62 (33.88)	121 (66.12)	335 (100)
Household Size*			
5 members or less	118 (23.94)	375 (76.06)	493 (100)
More than 5 members	52 (39.10)	81 (60.90)	133 (100)
Head of HH Origin**			
Migrant to Galapagos	134 (25.24)	397 (74.76)	531 (100)
Native to Galapagos	36 (37.89)	59 (62.11)	95 (100)

*** $p<0.001$, ** $p<0.01$, * $p<0.05$ denotes chi-square test significance

72% of the respondents achieved the highest possible variety sub-component score of 20. Significant differences in chi-square tests for whether or not the highest possible variety score was achieved are shown above in Table 2. In rural areas, the percentage of respondents not achieving the highest variety score was approximately 39% in comparison to 24% in urban areas. In food insecure households, the percentage of respondents not achieving the highest variety score was approximately 34% in comparison to 23% in food secure households. In food insecure households, the percentage not achieving the highest variety score was approximately 34%, while it was 23% in food secure households. In households with more than 5 members, the percentage not achieving the highest variety score was approximately 39% as compared to 24% in households with five members or less. For respondents whose head of household was native to the Galapagos, the percentage of less-than-highest variety scores was approximately 39% in comparison to 25% when the head of household migrated from elsewhere to the Galapagos.

Table 3. Socioeconomic predictors of diet quality and adequacy

Socioeconomic Variables	**DQI-I Score** Coef. (SE)	**Adequacy Score** Coef. (SE)
Urban/Rural # Island (ref. Urban # San Cristobal)		
Rural # San Cristobal	-3.02 (1.01) **	-2.32 (0.53) ***
Urban # Santa Cruz	-0.96 (0.61)	-0.65 (0.32) *
Rural # Santa Cruz	-0.47 (0.86)	-0.95 (0.45) *
Age Category (ref. older than 18)		
Less than 5	0.67 (0.97)	-0.44 (0.43)
5 – 12	1.84 (0.82) *	0.77 (0.32) *
12 – 18	1.47 (0.78)	0.23 (0.41)
Sex (ref. male)		
Female	-3.25 (0.53) ***	-2.5 (0.28) ***
Race Category (ref. Mestizo)		
Non-Mestizo	-2.03 (0.76) **	-1.43 (0.4) ***
HH Food Security (ref. food secure)		
Food Insecure	-0.88 (0.57)	-0.94 (0.3) **
Household Size (ref. less than 5)		
More than 5	-1.67 (0.64) *	-1.17 (0.34) **
Head of HH Origin (ref. migrant to Galapagos)		
Native to Galapagos	-3.39 (0.76) **	-1.1 (0.4) **
Head of HH Education (ref. primary or less)		
Secondary	-1.84 (0.6) **	-0.69 (0.32) *
Post-Secondary	0.03 (0.81)	0.79 (0.43)
Head of HH Marital Status (ref. married/partnered)		
Not Married or Partnered	-0.98 (0.53)	-0.61 (0.28) *
Constant	67.49 (1.02) ***	32.44 (0.47) ***
Observations	617	608
R-squared	0.14	0.24

* p<0.05, ** p<0.01, *** p<0.001

Predictors of DQI-I and adequacy sub-component scores in the overall sample

Table 3 (above) shows the multiple linear regression results for the socioeconomic predictors of total DQI-I scores and adequacy sub-component scores. Significant predictors of lower DQI-I and adequacy scores at the individual level included being female and non-Mestizo. Being in the 5 – 12 age group predicted higher DQI-I and adequacy scores. Significant predictors of lower DQI-I and adequacy scores at the household level included coming from a household with more than five members and living in rural San Cristobal in comparison to urban San

Cristobal. Heads of households that were native to the Galapagos Islands, not married or partnered, and educated at the secondary level in reference to primary or lower significantly predicted lower DQI-I and adequacy scores. Living in either urban or rural Santa Cruz compared to urban San Cristobal, being from a food insecure household, and having a head of household that is unmarried or unpartnered significantly predicted lower adequacy scores.

Predictors of adequate intake of iron and calcium in children under 18

Table 4 (below) shows the mean adequacy scores for iron, and calcium. The mean scores for adequate calcium for both males and females represented approximately 50% of the RDA for calcium. Mean adequate iron intake scores for females were lower at 1.95 (representing 39% of the RDA achieved) in comparison to 3.98 for males (representing 79% of the RDA achieved).

Table 4. Children's mean scores for adequate iron and calcium

DQI-I Adequacy Score	**Male**		**Female**	
	Mean Score (SD)	% RDA	Mean Score (SD)	% RDA
Iron	3.98 (0.89)	0.79	1.95 (0.67)	0.39
Calcium	2.46 (0.97)	0.49	2.52 (0.97)	0.50

*Maximum DQI-I component score for each is 5 points

Table 5 (below) shows the multiple linear regression results for the predictors of the percentage of the recommended daily intake of iron and calcium achieved. The RDA for iron achieved was significantly associated with the sex and age group interaction. In comparison to males over age 18, significant age-sex interaction predictors of a lower achieved percentage of the iron RDA included being female and in the age groups of younger than 5 (negative 51%), 5 – 12 (negative 42%), and 12 – 18 (negative 38%). Males under age 5 predicted lower adequacy of iron as well (negative 9%).

Significant predictors of a lower achieved percentage of the RDA for calcium included being non-Mestizo (negative 7%), having an unmarried or unpartnered head of household (negative 5%), and living in household that either has more than five members (negative 6%), is food insecure (negative 6%), or is located in rural in reference to urban San Cristobal (negative 13%).

Table 5. Children's predictors of adequate iron and calcium intake

Socioeconomic Variable	**% of Iron RDI**	**% of Calcium RDI**
	Coef. (Robust SE)	Coef. (Robust SE)
Urban/Rural # Island (ref. Urban # San Cristobal)		
Rural # San Cristobal	-0.03 (0.03)	-0.13 (0.03) ***
Urban # Santa Cruz	0 (0.02)	-0.02 (0.04)
Rural # Santa Cruz	-0.02 (0.03)	-0.02 (0.02)
Sex # Age Category (ref. 12–18 # Male)		
Male # Less than 5	-0.09 (0.03) ***	
Male # 5 – 12	-0.01 (0.03)	
Female # Less than 5	-0.51 (0.03) ***	*Not included*
Female # 5-12	-0.42 (0.03) ***	
Female # 12-18	-0.38 (0.03) ***	
Race Category (ref. Mestizo)		
Non-Mestizo	-0.03 (0.02)	-0.07 (0.03) *
HH Food Security (ref. food secure)		
Food Insecure	-0.05 (0.02) **	-0.06 (0.02) **
Household Size (ref. less than 5)		
More than 5	*Not included*	-0.06 (0.02) *
Head of HH Origin (ref. migrant to Galapagos)		
Native to Galapagos	-0.05 (0.02)	0.05 (0.03)
Head of HH Education (ref. primary or less)		
Secondary	-0.02 (0.02)	0 (0.02)
Post-Secondary	0.02 (0.03)	0.06 (0.03)
Head of HH Marital Status (ref. married/partnered)		
Not Married or Partnered	*Not included*	-0.05 (0.02) **
Constant	0.87 (0.03) ***	0.55 (0.03)
R-squared	0.68	0.15
Observations	345	340

*** p<0.001, ** p<0.01, * p<0.05

Discussion

Diet Quality in the Overall Sample

In this study, women had lower dietary quality and adequacy. Poor dietary adequacy appears to explain much of the decrease in total DQI-I scores for women. The largest sex differences for adequacy components existed for iron, due to the higher recommended intakes for women due to menstruation. Identifying with ethnicity other than Mestizo was associated with poorer dietary quality and adequacy. The majority of non-Mestizo respondents identified as Indigenous. This finding corresponded to a study which found that women from the indigenous Mah Meri ethnic group had lower diet quality compared to women from non-indigenous in Malaysia (Chong, Appannah, & Sulaiman, 2019).

Having an unmarried or unpartnered head of household was negatively associated with dietary adequacy. Chong et. al (2019) also found that single, divorced, or widowed aboriginal women from the Mah Meri ethic group in Malaysia were associated that poorer diet quality. Alkerwi et al. (2015) found that living alone in Luxembourg were associated with poorer dietary diversity and suggested that less family support and financial resources possibly contribute to poorer diet for unmarried or unpartnered women. Being in the 5 – 12 age group was associated with better diet quality and adequacy. Previous research on Isabela and San Cristobel islands in Galapagos has found that mothers prefer to be thinner, but desire for their children to be larger (Pera, Katz, & Bentley 2019; Waldrop, Page, & Bentley 2016). While this parenting norm could contribute to possible overweight or obesity, the focus on ensuring that children are eating enough food to be "large" likely contributes to the higher diet quality and adequacy in the 5 – 12 age group.

The household wealth index used in ENSANUT-ECU was not a significant predictor of diet quality, but heads of households with secondary in comparison to primary or lower had significantly lower diet quality in both the overall and child groups. While the education system is uniform across Ecuador, the uniqueness of the Galapagos context may not map well with the household wealth index conceptualized to capture wealth nationally. However, household food insecurity was negatively associated with dietary quality and adequacy. Household food security status was associated with whether a perfect variety score was achieved. Additionally, households with more than five members were associated with poorer diet quality and adequacy. They also had twice the percentage of respondents achieving a less than perfect variety score than households with less than five members.

Several other studies have found that diet quality is negatively associated with food insecurity in low income households (Leung et al, 2015; Heut et. al, 2012; Darmon & Drewnowski, 2015). In the United States, data from the 2001– 2002 NHANES database showed that food-insecure households had lower estimated diet costs, while higher socioeconomic status groups had higher diet quality and higher estimated energy-adjusted diet costs (Ryden & Hagfors, 2011). Freire et al. (2018) found that barriers to healthy diets in Galapagos include price, availability, and quality of fresh produce, in addition to as easy access to industrialized processed and ultra-processed foods.

Respondents with heads of households that were native to the Galapagos had significantly lower diet quality and adequacy. Additionally, these respondents had a higher percentage of respondents achieving a less than perfect variety score than those with a married or partnered head of household. This finding suggests that migrants to the Galapagos were perhaps socially and economically positioned to achieve better diet quality that those who were born there. Interventions that aim to improve nutritional health in Galapagos should consider the differences between those native to Galapagos versus those who migrate to Galapagos.

Adequacy of Iron and Calcium for Children

Adequate iron intake has been linked to healthy cognitive development in children in the nutritional epidemiology literature, while poor calcium intake has been linked with stunting (Lozoff 1988; Pollitt 1993; Stuijvenberg et al., 2015). While sex was not associated with differences in adequate intake of calcium, being female was negatively associated with adequate iron intake. The multiple linear regression model predicted lower achieved percentage of the iron RDA for women in all age groups, with younger women faring worse than older women. Boys younger than 5 also had lower iron adequacy. Educational interventions that aim to increase iron intake should focus on mothers and children.

While race was not associated with iron intake, respondents who were non-Mestizo had less adequate intake of calcium. As was the case with diet quality in the analysis of the overall sample, food insecure households were negatively associated with lower adequate intake of iron and calcium. In multiple linear regression, rural San Cristobal in particular predicted 13% lower achieved percentage of the RDA for calcium. Additionally, households that had more than 5 members, and those with an unmarried or unpartnered household head were associated with lower calcium adequacy. These findings aligned with the findings of previous studies mentioned in the previous discussion section on diet quality in the overall sample.

Strengths and Limitations

This study contributed to the small, but increasing amount of research on human health in Galapagos. The DQI-I allowed for a nuanced assessment of diet quality that extended beyond just examining variety or adequacy of certain nutrients or food groups. A limitation to this study was that the 24-hour dietary recall method used in ENSANUT-ECU is only a “best estimate” of dietary intake and therefore does not reflect accurate intake. Bias is also likely with this method because respondents can easily over- or -under-report dietary intake. Furthermore, the data may be biased because only a single 24-hour dietary recall was used instead of multiple iterations of 24-hour recalls, which helps reduce the bias due to recall difficulties and the potential variation of diet from day to day.

Additionally, the cross-sectional nature of the study does not allow for cause and effect relationships to be determined. Data on empty calorie foods, a unique sub-component of the DQI-I that would have been interesting to examine, were not available for this study. Lastly, these data may not reflect the current reality on the islands because data ENSANUT-ECU were collected in 2012.

Conclusion

As Galapagos continues to rapidly change, pressures on human health will continue to increase. While the findings in this study are align with findings in similar studies around the world, residents face unique challenges due to the isolation of the islands. Food systems in Galapagos are impacted by the tourism industry and land and biodiversity regulations. A study that modeled food supply system dynamics estimated that by 2037 the 95% of the agricultural food supply will be imported from mainland Ecuador (Sampedro et al., 2015). Policies promoting and incentivizing local agricultural growth have been suggested as potential solutions to the nutritional and health issues the islands are facing. For local interventions, Friere et al. (2018) suggests promoting family, community, and school gardens in combination with a multi-faceted education program aimed at parents and children.

Ecuador has demonstrated its progressive stance on nutritional health through its support of a World Health Assembly resolution that sought to promote breastfeeding and decrease harmful marketing of infant formula (New York Times, 2018). However, the United States threats to remove military support from Ecuador over its support for the resolution highlighted the power imbalances at play within global health policy. Policy-level interventions, such as ones that tax sugar-sweetened beverages or promote warning labels against unhealthy foods, may face similar roadblocks. As long as Galapagos overwhelmingly depends on imports, processed foods will continue to reign dominant residents' diets. Friere et. al (2018) recently described Galapagos as a "window on the world" in regards to the processes contributing to the rise in the global prevalence of obesity. To further this analogy, I argue that the steps that Galapagos takes to address their changing food systems dual burden of OWT/NCD and UWT/ID can provide insights for interventions elsewhere.

Appendix 1. DQI-I scoring breakdown

Component	Score	Scoring criteria
Total	0-100	
Variety	0–20	
Overall food group variety (meat/poultry/fish/eggs; dairy/ beans; grain; fruit; vegetable)	0–15	1 serving from each food group/d = 15 Any 1 food group missing/d = 12 Any 2 food groups missing/d = 9 Any 3 food groups missing/d = 6 4 food groups missing/d = 3 None from any food groups = 0
Within-group variety for protein source (meat, poultry, fish, dairy, beans, eggs)	0–5	3 different sources/d = 5 2 different sources/d = 3 From 1 source/d = 1 None = 0
Adequacy	0-40	
Vegetable group	0–5	≥ 3–5 servings/d = 5, 0 servings/d = 0
Fruit group	0–5	≥ 2–4 servings/d = 5, 0 servings/d = 0
Grain group	0–5	≥ 6–11 servings/d = 5, 0 servings/d = 0
Fiber	0–5	≥ 20–30 g/d = 5, 0 g/d = 0
Protein	0–5	≥ 10% of energy/d = 5, 0% of energy/d = 0
Iron	0–5	≥ 100% RDA/d 5, 0% RDA/d = 0
Calcium3	0–5	≥ 100% RDA/d 5, 0% RDA/d = 0
Vitamin C	0–5	≥ 100% RDA/d 5, 0% RDA/d = 0
Moderation	0–30	
Total fat	0–6	≤ 20% of total energy/d = 6 > 20–30% of total energy/d = 3 > 30% of total energy/d = 0
Saturated fat	0–6	≤ 7% of total energy/d = 6 > 7-10% of total energy/d = 3 > 10% of total energy/d = 0
Cholesterol	0–6	≤ 300 mg/d = 6 > 300–400 mg/d = 3 > 400mg/d = 0
Sodium	0–6	≤ 2400 mg/d = 6 > 2400–3400 mg/d = 3 > 3400 mg/d = 0
Empty calorie foods*	0–6	≤ 3% of total energy/d = 6 > 3-10% of total energy/d = 3 > 10% of total energy/d = 0
Overall balance	0–10	
Macronutrient ratio (carbohydrate:protein:fat)	0–6	55 ~ 65:10 ~ 15:15 ~ 25 = 6 52 ~ 68:9 ~ 16:13 ~ 27 = 4 50 ~ 70:8 ~ 17:12 ~ 30 = 2 Otherwise = 0
Fatty acid ratio (PUFA:MUFA:SFA)	0–4	P/S = 1 ~ 1.5 and M/S = 1 ~ 1.5 = 4 Else if P/S = 0.8 ~ 1.7 and M/S = 0.8 ~ 1.7 = 2 Otherwise 0

*Data on empty calorie foods were not available for this study

Sources

Alkerwi, A., Vernier, C., Sauvageot, N., Crichton, G. E., & Elias, M. F. (2015). Demographic and socioeconomic disparity in nutrition: Application of a novel Correlated Component Regression approach. *BMJ Open,* 5(5). doi:10.1136/bmjopen-2014-006814

Chong, S., Appannah, G., & Sulaiman, N. (2019). Predictors of Diet Quality as Measured by Malaysian Healthy Eating Index among Aboriginal Women (Mah Meri) in Malaysia. *Nutrients*, 11(1), 135. doi:10.3390/nu11010135

Darmon, N.; Drewnowski, A. (2015). Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: A systematic review and analysis. *Nutr. Rev*, *73*, 643–660.

Doak CM, Adair LS, Monteiro C, Popkin BM. (2000). Overweight and underweight coexist within households in Brazil, China and Russia. *J Nutr.* 130:2965–2971

Doak CM, Adair LS, Bentley M, Monteiro C, Popkin BM. (2005). The dual burden household and the nutrition transition paradox. *Int J Obes.* 29:129–136.

Fernald LC, Neufeld LM. (2007) Overweight with concurrent stunting in very young children from rural Mexico: prevalence and associated factors. *European journal of clinical nutrition.* 61(5):623-632.

Freire, W. B., Waters, W. F., Román, D., Jiménez, E., Burgos, E., & Belmont, P. (2018). Overweight, obesity, and food consumption in Galapagos, Ecuador: a window on the world. *Globalization and health*, *14*(1), 93. doi:10.1186/s12992-018-0409-y

Freire WB, Silva KM, Ramirez MJ, Waters WF, Larrea AP. (2014) The double burden of undernutrition and excess body weight in Ecuador. *Am J Clin Nutr.*; 100(suppl):1636S–43S.

Freire, WB, Ramírez-Luzuriaga, MJ, Belmont, P, Mendieta, MJ, Silva-Jaramillo, KM, Romero, N, Sáenz, K, Piñeiros, P, Gómez, L and Monge, R (2013), *Encuesta Nacional de Salud y Nutrición ENSANUT-ECU 2011-2013. Tomo I.* Quito, Ecuador.

Freire W, Ramirez-Luzuriaga M, Belmont P. (2015) Tomo I: Encuesta Nacional de Salud y Nutrición de la población ecuatoriana de cero a 59 años, ENSANUT-ECU 2012. *Revista Latinoamericana de Políticas y Acción Pública Volumen 2, Número 1-mayo 2015.* 2(1):117.

Gerber, M (2001). The comprehensive approach to diet: a critical review. J. Nutr. 131(suppl. 11): 3051S–3055S.

Griffiths PL, Bentley ME. (2001). The nutrition transition is underway in India. *J Nutr.* 131:2692–2700

Hébert, J. R., Hurley, T. G., Steck, S. E., Miller, D. R., Tabung, F. K., Peterson, K. E., . . . Frongillo, E. A. (2014). Considering the Value of Dietary Assessment Data in Informing Nutrition-Related Health Policy. Advances in Nutrition, 5(4), 447-455. doi:10.3945/an.114.006189

Huet, C.; Rosol, R.; Egeland, G.M. (2012). The prevalence of food insecurity is high and the diet quality poor in Inuit Communities. *J. Nutr,* 142, 541–547.

INEC (Instituto Nacional de Estadística y Censo). Censo de población y vivienda Galápagos. Quito: INEC. 2015. http://www.ecuadorencifras.gob.ec/ censo-de-poblacion-y-vivienda-galapagos/Accessed 23 Aug 2018.

Jacobs, A. (2018, July 08). Opposition to Breast-Feeding Resolution by U.S. Stuns World Health Officials. Retrieved from https://www.nytimes.com/2018/07/08/health/world-health-breastfeeding-ecuador-trump.html

Kant, A. K. (1996). Indexes of overall diet quality: a review. *J. Am. Diet. Assoc.* 96: 785–791.

Kim, S., Haines, P. S., Siega-Riz, A. M., & Popkin, B. M. (2003). The Diet Quality Index-International (DQI-I) Provides an Effective Tool for Cross-National Comparison of Diet Quality as Illustrated by China and the United States. *The Journal of Nutrition*, 133(11), 3476-3484. doi:10.1093/jn/133.11.3476

Larrea C. Demografía y estructura social en Galápagos: 1990-2008 (Demography and social structure in Galapagos: 1990-2008). (2008) Quito: Universidad Andina Simon Bolivar. http://repositorio.uasb.edu.ec/bitstream/ 10644/855/1/LARREAC-CON0007-GALAPAGOS.pdf

Lee J, Houser RF, Must A, de Fulladolsa PP, Bermudez OI. (2010). Disentangling nutritional factors and household characteristics related to child stunting and maternal overweight in Guatemala. *Econ Hum Biol.* 8(2):188-196.

Leung, C.W., Epel, E.S., Ritchie, L.D.,Crawford, P.B., Laraia, B.A. (2015). Food insecurity is inversely associated with diet quality of lower-income adults. *J. Acad. Nutr. Diet.*, *114,* 1943–1953.

Lozoff, B. (1988). "Behavioral alterations in iron deficiency." *Advances in Pediatrics* 35 : 331–60.

Ma, Y., Olendzki, B. C., Pagoto, S. L., Hurley, T. G., Magner, R. P., Ockene, I. S., … Hébert, J. R. (2009). Number of 24-hour diet recalls needed to estimate energy intake. *Annals of epidemiology*, 19(8), 553–559. doi:10.1016/j.annepidem.2009.04.010

Mariscal-Arcas, M., Romaguera, D., Rivas, A., Feriche, B., Pons, A., Tur, J., & Olea-Serrano, F. (2007). Diet quality of young people in southern Spain evaluated by a Mediterranean adaptation of the Diet Quality Index-International (DQI-I). *British Journal of Nutrition,* 98(6), 1267-1273. doi:10.1017/S0007114507781424

Page R, Bentley M, Waldrop J. (2013). People live here: maternal and child health on Isla Isabela, Galápagos.Science and Conservation in the Galapagos Islands: Springer. 141-153.

Pera, M. F., Katz, B. N., & Bentley, M. E. (2019). Dietary Diversity, Food Security, and Body Image among Women and Children on San Cristobal Island, Galapagos. *Maternal and Child Health Journal*. doi:10.1007/s10995-018-02701-4

Parque Nacional Galapagos Ecuador (2011). http://www.galapagospark.org.

Patterson, R. E., Haines, P. S. & Popkin, B. M. (1994) Diet Quality Index: Capturing a multidimensional behavior. *J. Am. Diet. Assoc*. 94: 57–64.

Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. Nutrition reviews, 70(1), 3-21.

Pollitt, E. (1993). "Iron deficiency and cognitive function." *Annual Review of Nutrition* 13 : 521–37.

Rehm CD, Monsivais P, Drewnowski A. (2011). The quality and monetary value of diets consumed by adults in the United States. *Am J Clin Nutr*, 94:1333–1339.

Ryden PJ, Hagfors L. (2011). Diet cost, diet quality and socio-economic position: how are they related and what contributes to differences in diet costs? *Public Health Nutr*, 14:1680–1692.

Sampedro C, Pizzitutti F, Quiroga D, Walsh SJ, Mena CF (2018). Food supply system dynamics in the Galapagos Islands: agriculture, livestock and imports. *Renewable Agriculture and Food Systems* 1–15. https://doi.org/10.1017/S1742170518000534

Stuijvenberg, M. E., Nel, J., Schoeman, S. E., Lombard, C. J., Plessis, L. M., & Dhansay, M. A. (2015). Low intake of calcium and vitamin D, but not zinc, iron or vitamin A, is associated with stunting in 2- to 5-year-old children. Nutrition, 31(6), 841-846. doi:10.1016/j.nut.2014.12.011

Tzioumis E, Adair LS. (2014). Childhood dual burden of under- and overnutrition in low- and middle-income countries: a critical review. *Food Nutr Bull.* 2014;35(2):230-243.

Waldrop, J., Page, R., & Bentley, M. (2016). Perceptions of body size in mothers and their young children in the Galapagos Islands. *Journal of Maternal and Child Health*, 20, 2012–2018.

Walsh SJ, McCleary AL, Heumann BW, Brewington L, Raczkowski EJ, Mena CF. (2010). Community expansion and infrastructure development: implications for human health and environmental quality in the Galápagos Islands of Ecuador. *Journal of Latin American Geography,* 9(3):137-159.

Walsh SJ, Mena CF. (2013). Perspectives for the study of the Galapagos Islands: Complex systems and human–environment interactions. *Science and conservation in the Galapagos Islands*: Springer, 49-67.