A STUDY OF DIET COMPOSITION AND TRANSITION AMONG INDIGENOUS COMMUNITIES IN THE NORTHERN ECUADORIAN AMAZON

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ABSTRACT

Gioia M. Skeltis: A Study of Diet Composition and Transition among Indigenous Communities in the Northern Ecuadorian Amazon (Under the direction of Mark Sorensen)

Many indigenous communities have undergone epidemiological and nutritional transitions as urbanization places them closer to non-local markets. This study assesses diet composition and variation among a cross-cultural sample of Cofán, Huaorani, Kichwa, Secoya, and Shuar communities to better understand how diet may serve as an early predictor of nutritional transition in the Northern Ecuadorian Amazon. Food consumption was measured in 311 adults from eight communities using the repeated 24-hour recall method (n=4204). The sample shows that communities maintain access to forest fruits, vegetables, and animals. However, frequency and diversity of market foods suggest that communities are vulnerable to changes in diet composition. Dietary differences persist within and between indigenous groups. Diet composition and variation point to urbanization as a key driver of changing diet patterns. Future analyses of nutrient intakes and biomarker profiles will afford greater insights for alleviating dual burden of nutrition as stressors of market integration intensify.
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INTRODUCTION

As technological advancements make our world ever more connected, low- and middle-income countries are pressured to establish footing in the greater global economy to secure their own national interests. This pressure greatly underlies urbanization, a process wherein rapid changes in socioeconomic and land-use structures drive a traditional society towards being more metropolitan (Elmqvist et al., 2013). Adequate infrastructure must be in place in order to implement and support a range of trade networks, commercial industries, and social services (Schaeffer, 2016). Efforts have brought about radical changes for communities living in these regions, impacting many lifestyle factors like socioeconomic status, education, housing and sanitation, and access to healthcare. Previous research has identified many of these variables as underlying causes of health and illness or disease, known as “social determinants” (Blane, 1995). Indeed, changes caused by rapid urbanization have had serious ramifications for health. In low- and middle-income countries specifically, communities continue to experience higher rates of infectious disease and have recently been exposed to chronic diseases associated with high-income countries (Omran, 1983). Much of this can be attributed to the fast pace at which livelihoods shift when communities transition from rural to urban (Omran, 1983). The increased flow of imported and commercial (processed) foodstuffs into local markets has sparked dietary changes, which in turn put households at risk for both under- and over-nutrition (Popkin, 2002). This dual nutritional burden is exacerbated by social inequality and health inequity and suggests
that market integration, the linkage of local markets with larger (regional, national, etc.) markets, is an important predictor of health in urbanizing areas (Gurven et al., 2015; Wilkinson, 1996).

One such region is the Northern Ecuadorian Amazon, which has become a magnet for development as petroleum extraction, logging, and tourism industries expand. In 2009, Flora Lu and Mark Sorensen sought to investigate how these activities were affecting health among local indigenous communities by looking at measures of market integration. Assessments of indigenous health are needed to understand patterns of local disease ecology and health disparities in the region, and the role that market integration plays in these patterns. Since the urban diet is a key marker of nutrition transition and risk for dual nutritional burden, food consumption is an important measure of current and future health in the Ecuadorian Amazon. This study will analyze diet data from Lu and Sorensen’s project to advance our understanding of dietary trends among indigenous communities with increasing urbanization in the area. In doing so, this study will investigate the following research questions:

(1) What is the diet composition in each community?

(2) How does diet vary across indigenous groups and communities?

(3) What is the prevalence and distribution of market foods in each community?

Given these objectives, this study aims to illuminate differences in diet composition and variation, and assess diversity and distribution of market foods, at the community level. This will be accomplished by standardizing the repeated 24-hour recalls collected during the research project into a cohesive data set, producing a cleaned master list of all consumed food items, creating food groups, assigning each food item to the appropriate food group, and comparing food sources. Statistical testing will analyze diet composition and variation across all participating indigenous groups and communities, identify significant dietary differences, and
calculate prevalence of market foods. Future analyses will use this study’s findings to generate nutrition profiles and identify nutritional deficits at the household and community levels. These profiles will ultimately be paired with collected biomarker samples to illuminate patterns of dual nutritional burden and risk for infectious and chronic disease.
CHAPTER 1: THEORETICAL FRAMEWORK

The epidemiological transition model

Although demographic transition theory emerged to explain dynamics of population change, its ability to contextualize complex, changing patterns of human health and disease is limited. To fill this gap, Abdel Omran developed the epidemiological transition theory, which explains how health trends relate to their demographic, economic, and social determinants and consequences (1971). The underlying principles of this theory work to demonstrate how leading causes of morbidity and mortality shift from infectious pandemics to chronic diseases in urbanizing areas during an epidemiological transition. Specifically, the theory’s five precepts state that:

1. Mortality is an intrinsic part of population dynamics.
2. Burdens of morbidity and mortality shift from infectious diseases to chronic, noncommunicable diseases (NCDs). This pattern typically unfolds in three successive stages: pestilence and famine, receding pandemics, and NCDs.
3. The most pronounced changes in health and disease patterns occur in (young) children and women of reproductive age.
4. Changes in health and disease are linked to demographic and socioeconomic transitions.
5. The actual observed pattern, pace, determinants, and consequences of population change are variable.
Historically, three distinct types, or variants, of epidemiological transitions have been recorded during the past three centuries. Each is represented by a model and intends to bridge demographic change with shifts in patterns of health and disease. The classical (Western) model describes populations that moved from foraging subsistence practices to primary food production during the Neolithic period, a shift marked by plant and animal domestication, increased population size and density, sedentariness, and greater social stratification (Armelagos et al., 2005). As a result of these changes, populations began a gradual transition from high mortality and high fertility to low mortality and low fertility (Omran, 1971). This model largely characterizes Western European societies, which moved from episodes of famine during the “pre-modern” and “early modern” eras to industrialization and urbanization by the early twentieth century (Omran, 1971). The accelerated model is similar to the classical model in most respects, except that mortality decreased much faster. A prime example of this is post-World War II Japan, where chronic diseases replaced infectious diseases as the main causes for morbidity and mortality within the short span of a few decades (Omran, 1983). Last is the contemporary model, which is an extension of Omran’s model to understand more modern health trends. As its name suggests, the contemporary model refers to recent and ongoing transitions in many low- and middle-income countries undergoing urbanization. Like their Western counterparts, populations in these countries have been introduced to a breadth of NCDs, which have expanded out from urban centers into rural communities (Azcorra et al., 2013). Despite this similarity, the actual burdens of disease and deaths are very disproportionate. Of the total deaths from NCDs globally, over 75% of them occur in low- and middle-income countries (WHO, 2017). Disease burden and ecology have been further compounded by the “reemergence” of several antibiotic- and pesticide-resistant infectious diseases (Armelagos et al., 2005). Lower
respiratory infections, diarrheal diseases, tuberculosis, malaria, and HIV/AIDS remain at the forefront of infectious disease burden, with each causing over 1 million deaths worldwide in 2015 (WHO, 2017). Primary causes of death in low-income countries further include maternal causes, pregnancy and childbirth complications, and nutritional deficiencies (WHO, 2017).

Many public health campaigns during the twentieth century sought to eradicate “emerging” infectious diseases by targeting the relationship between hosts, pathogens, and the environment (Turshen, 1977). As Meredith Turshen and Paul Farmer point out though, this approach failed in many respects because it did not consider the greater political-economic contexts of health and illness (Farmer, 1996; Turshen, 1977). Anthropological explanations for these blatant health disparities hinge on Richard Wilkinson’s hypothesis, which states that differential health outcomes between the social classes is best predicted by the size of the gap between the wealthy and poor rather than the average income of the society at large (Armelagos et al., 2005; Wilkinson, 1996). Economic and technological advancements tend to widen the gap between the social classes, thus reinforcing a vicious cycle in which the wealthy become wealthier and healthier while the poor become poorer and sicker (Wilkinson, 1996). Present within and between countries, social inequality and inequity in health accelerate the spread of emerging and reemerging diseases and point to poverty as a key determinant of “unnecessary, premature, preventable disease and death” on the global scale (Armelagos et al., 2005:757; Farmer, 1996).

The nutrition transition model

As indicated by Omran’s contemporary model, numerous factors must converge in order to shape particular characteristics of a population (2001). Like epidemiological patterns, nutrition
has also changed, and recent research has emphasized its role in untangling the relationship between urbanization processes and health outcomes. Called “the nutrition transition,” this change is characterized as a shift in dietary and energy expenditure (physical activity) patterns from a healthier diet and higher physical activity to a poorer diet and lower physical activity (Popkin, 2002). Since diet and physical activity are paired with changes in health, demographics, and socioeconomic status (SES), the logistics of a nutrition transition can be better understood by breaking it down into five sub-patterns, or phases, of historical developments (Popkin, 2002). First proposed by Barry Popkin, these phases are not constrained to certain time periods in human history but, rather, are intended merely to describe the stages which ultimately lead to a nutrition transition. The sequence, adapted from Popkin (2002), is as follows:

1. **Collecting food.** This diet, commonly found among hunter-gatherer societies, is high in fiber and carbohydrates and low in (saturated) fat. Most polyunsaturated fat is consumed from the meat of wild hunted animals as opposed to domesticated livestock. Physical activity is very high, resulting in low rates of overweight/obesity. Morbidity and mortality are greatly attributed to extrinsic pathogens, through parasitic and infectious diseases.

2. **Famine.** The diet becomes less diverse, with starchy foods like corn, rice, wheat, etc., emerging as staples. Mass (agricultural) production of these foods increases susceptibility to periods of food scarcity and famine. Social stratification hardens during this time, with dietary variation often hinged on gender and social status. Main types of physical activity shift to predominantly agricultural labor, but the actual amount or level of activity remains relatively consistent with previous levels. Infectious disease continues to be a major cause of morbidity and mortality but, with
increased population density, illness is often spread on a much larger scale through plagues and epidemics.

3. *Receding famine*. Fruit, vegetables, and animal protein become more prevalent in the diet, with reduced reliance on starchy staple foods. This diversification reduces future risk of famine, as many of these foods are not as sensitive to drought, flood, or other weather patterns. Accompanying this altered diet, types of physical activity begin to shift, and activity levels begin to decline as people have more time for leisure (inactivity).

4. *Nutrition-related non-communicable disease (NR-NCD)*. The typical diet is high in total fat, cholesterol, sugar, and empty carbohydrates. Furthermore, it is low in fiber and polyunsaturated fatty acids. Low physical activity level, also known as “sedentariness,” is commonplace. It is during this pattern that populations are more at risk for obesity and other degenerative, chronic illnesses.

5. *Behavioral change*. A new diet surfaces to delay or even prevent NR-NCDs associated with poor diet. Consumers and government policies alike target diet and body composition as critical points for intervention through behavioral lifestyle changes. Greater emphasis is also placed on increasing physical activity during leisure time. With these changes, it is anticipated that morbidity and mortality will be curtailed and that, as a result, quality of life and life expectancy may increase. The long-term effects of this have not yet been realized though, as this pattern is currently underway in several different, predominantly high-income, countries such as the United States.
Although the historical timing of these patterns varies, Popkin and others are concerned with the rate at which many low- and middle-income countries over the past two decades have been moving from periods of receding famine to NR-NCD (Pattern Three to Pattern Four) (1999; Amuna and Zotor, 2008). In many urbanizing regions, these dietary and physical activity shifts are occurring so quickly that they appear to overlap, posing serious implications for nutrition, disease ecology, and disease burden (Popkin, 1999). During times of receding famine (Pattern Three), physical activity levels are lower because subsistence strategies require less physical labor and infectious and parasitic diseases are prevalent; however, rapid transitions to Pattern Four combines this with a diet of poorer quality and introduces populations to chronic illnesses (Popkin et al., 2012). With a foot in both stages, populations in low- and middle-income countries are at elevated risk of suffering from communicable and non-communicable diseases simultaneously. This is due, in part, to a calorically high but very nutrient-poor diet, and can lead to what is more formally known as “dual burden of nutrition” (Amuna and Zotor, 2008).

**Dual burden of nutrition**

A relatively new pattern, the dual burden of nutrition refers to the presence of both under- and over-nutrition, measured in populations by risk for underweight or stunting/anemia and overweight/obesity (Popkin et al., 2012). Today, this is most common in low- and middle-income countries undergoing urbanization, as demographic and socioeconomic shifts prompt dietary and other lifestyle changes (Caballero, 2005). It is usually manifested by underweight/stunting in children and overweight/obesity in adults, although this and many other combinations can persist at the community, household, and even individual level (Tzioumis and Adair, 2014). At the community level, SES may be a strong driver for the degree of dual burden,
considering that over-nutrition is increasingly prevalent among the already undernourished poor (Ruel et al., 2001). Within a household, food resources may be divided unevenly, resulting in disparate nutritional status between family members and across generations (Ruel et al., 2001; Tzioumis and Adair, 2014). Dual burden may also be present in an individual because stunting or anemia and overweight/obesity share underlying (dietary) determinants (Tzioumis and Adair, 2014). Although the reasons behind this have not been fully realized, dietary energy intake in poorer individuals may be restricted by food insecurity, and energy demands of manual labor and daily activities may “make it difficult…to achieve a net positive energy balance and therefore to gain weight” (Caballero, 2005:1514). At the same time though, people living in or near urban centers can access cheap, energy-dense foodstuffs more easily (Popkin et al., 2012). Herein lies the core of dual nutritional burden: Introduced commercial foods may meet or even exceed minimum caloric intake, but they are essentially “empty” calories because they fail to meet basic nutritional requirements. As a result, individuals are at risk of developing affiliated chronic illnesses and health conditions. This relationship between nutritional change and dual nutritional burden will now be conceptualized more fully in two case studies. The first speaks more broadly to the emergence of dual burden households in various populations around the globe, whereas the second traces dietary changes in a specific community.

Colleen Doak et al.’s cross-national study sought to document the prevalence of dual burden households in a cross-sectional sample and assess the correlation between nutritional status and income and urban residence (2005). Data was collected from national surveys in seven different countries, which included Russia, the Kyrgyz Republic, Vietnam, China, Indonesia, Brazil, and the United States. Study participants were classified into underweight and overweight categories, and households were categorized as being either dual burden, overweight,
underweight, or normal. Income and urban residence were then analyzed as potential risk factors in dual burden households. Results were startling: In six of the seven countries, between twenty-two and sixty-six percent of households had both an underweight member and an overweight member. Consistent with earlier findings, middle-income countries exhibited the highest prevalence of dual burden households. As an extension of this, dual burden households were more likely to live in urban areas.

Hugo Azcorra et al.’s study hones in on the effects of nutrition transition within the context of a traditional Mayan community with the population, mother-child dyads, and individuals (2013). Fifty-eight mother-child dyads living in Merida, Yucatan, Mexico, were recruited to track dietary patterns and changes via food frequency questionnaires (FFQs). The FFQs were comprised of seventy-eight food items and four levels of frequency consumption (no, low, medium, and high). Although the data was self-reported, they indicate low consumption of fruits and vegetables, medium consumption of eggs, pork, oil, and lard, and high consumption of soda and whole milk. These food frequencies point to diets that are low in fiber and micronutrients, but high in fat and sugars. Bolstered by other regional and national studies, this research suggests that Mayan (and other indigenous) communities are moving away from healthier, traditional diets.

Whereas infectious and parasitic diseases have been common in many low- and middle-income countries, chronic degenerative diseases have only recently become major contributors to disease ecology and burden. The greatest impact can be seen in middle-income countries, where overweight is now one of the top ten leading causes of morbidity, on par with rates of overweight in high-income countries (Caballero, 2005). Furthermore, dual nutritional burden, and overnutrition in particular, contribute to major mortality outcomes globally. Coronary artery
disease (IHD) and cerebrovascular disease are listed in the top ten leading causes of death in both high-income and middle-income countries (Amuna and Zotor, 2008). Much concern should be directed towards alleviating dual burden in low-income countries, too. Latin America is experiencing a pandemic of chronic diseases. Brazil and Mexico are among the top ten countries in the world for number of diabetes cases (Cuevas et al., 2009). Additionally, the cross-cultural CARMELA study found that prevalence of metabolic syndrome across several Latin American cities ranged from 14% in Quito to 27% in Mexico City (Cuevas, et al., 2009). It is predicted that these health problems will worsen as countries urbanize and engage in global markets (Cuevas et al., 2009).

**Epidemiological and nutritional patterns in Ecuador**

Ecuador is one of many middle-income countries facing these epidemiological and nutritional challenges. Chronic childhood undernutrition remains a severe health problem at the national level, as it was reported in 2009 that 23% of children under the age of 5 years were stunted, and 6% were underweight (UNICEF). Recent changes in dietary patterns have also affected nutritional burden. As the country has gained traction in larger regional and global markets, commercial foodstuffs have become more readily available. Many of these products are processed foods high in calories, refined carbohydrates and sugars, and saturated fats (Popkin, 1998). They contrast sharply with the staples of the more traditional low-calorie, plant-based diet, and their increased consumption makes it difficult for individuals, especially children, to meet their basic nutritional needs (Bernstein, 2008; Dufour et al., 2016). In fact, the World Bank reported that 23% of Ecuadorian children under the age of five years are stunted, and 6% are underweight (2011). The WHO also reported that 15% of preschool-aged children had Vitamin
A deficiency, while 38% of preschool-aged children and 38% of pregnant women had iron-deficiency anemia (2009, 2008). Although the numbers of children who are overweight and underweight in Ecuador are roughly equivalent, overweight is increasing (World Bank, 2013). Of Ecuadorians aged fifteen and older, 36% are overweight and 14% are obese (World Bank, 2013). These dietary mismatches between basal caloric and nutritional intake suggests that many Ecuadorian communities and households may already be suffering from the effects of dual nutritional burden.

These epidemiological and nutritional trends within Ecuador are exacerbated in the Amazon, where proximity to petroleum extraction, deforestation, and a growing tourism industry pressures indigenous communities to engage with larger markets (Holt et al., 2004; San Sebastián and Hurtig, 2004). Despite these activities, minimal infrastructure exists, and many communities do not have access to safe drinking water and other basic sanitation (Houck et al., 2013). This makes indigenous groups more vulnerable to contracting infectious diseases overall, as both children and adults have higher incidences of (lower) respiratory infections, gastrointestinal illness, and various vector-borne diseases than non-indigenous Ecuadorians (Kuang-Yao Pan et al., 2010). Furthermore, indigenous children are severely afflicted by chronic undernutrition. A recent study conducted among indigenous children/adolescents, aged 0-17 years, identified several key indicators of poor nutrition in the Peruvian Amazon: 51% had anemia, 50% were stunted, and 20% were underweight (Anticona and San Sebastián, 2014). These results are consistent with the 2004 finding that nearly half of indigenous children in Ecuador, aged 0-5 years, experienced compromised growth due to chronic undernutrition (Walker, 2007). Indigenous communities have also begun to shift away from traditional subsistence strategies by introducing non-local, commercial foods into their diets (Silva et al.,
This has been followed by unprecedented increases in cardiovascular and metabolic diseases among indigenous adults (Liebert et al., 2013; Silva et al., 2016). The presence of undernutrition and infectious disease in children and chronic disease in adults together emphasize the significance of urbanization processes in shaping epidemiological and nutritional trends in the Amazon (Dufour et al., 2016; Silva et al., 2016). More specifically, market integration has emerged as a key determinant of indigenous health (Gurven et al., 2015). Its socioeconomic effects are far-reaching, influencing diet, nutritional intake, and growth patterns in children, and putting adults at greater risk for chronic disease (Godoy and Cardenas, 2000; Godoy et al., 2000, 2010; Silva et al., 2016).
CHAPTER 2: METHODOLOGIES FOR DIETARY ASSESSMENT

Several methodologies have been developed and applied to illuminate epidemiological and nutritional trends over the past few decades. Since dual nutritional burden has become a more prevalent and pressing concern for global health, many of these tools have been adapted to identify vulnerable (at-risk) communities. A critical “first step” in this process is to collect information about normal food consumption and dietary patterns at the household and community levels. These data can then be used to calculate typical macro- and micro-nutrient intakes and predict nutritional deficits that could lead to under- and/or over-nutrition. Biomarker data also plays an important role, as they often yield supplementary information pertaining to an individual’s nutritional status and/or risk for infectious and chronic disease. Given the study’s research questions and objectives, this chapter will solely discuss traditional methods used to collect dietary data.

Dietary assessment

Examining food consumption and diet composition is essential when researching nutritional and epidemiological patterns in a given community or population (Gibson, 2005). These data can be used to generate individual dietary and nutrition profiles, which are frequently analyzed to describe respective trends among households, communities, and regions or countries. While biomarkers detect patterns of disease ecology and disease burden, diet data tries to explain what is driving these epidemiological trends. In countries where urbanization is occurring
rapidly, dietary and biomarker data may indicate dual nutritional burden: Together, they can help to identify prevalence and incidence of nutritional deficits and potential risk for chronic disease in individuals later in life. Since anthropological research most often measures food consumption within individuals, this chapter focuses on primary methods used at this scale. The set of methods discussed here therefore surveys six validated tools for dietary assessment: the 24-hour recall method, repeated 24-hour recall method, estimated food record, weighted food record, dietary history, and food frequency questionnaire (FFQ).

**24-hour recall method**

The “24-hour recall method” is a useful tool for assessing actual dietary intake because it requires individuals to recall their exact food intake within the past 24-hour period (or the preceding day, depending on the study design) (Gibson, 2005). This data is collected by research team members who are well-versed in interviewing techniques, as the 24-hour recall method is usually a four-stage process (Gibson and Ferguson, 1999). In the first stage, or “pass,” a complete list of all food and beverage items consumed during the past 24-hour period is recorded (Gibson and Ferguson, 1999). Study participants are then asked to provide more detailed information about consumed foods and beverages during the second pass, such as preparation/cooking methods or brand names (when applicable) (Gibson and Ferguson, 1999). During the third pass, participants are asked to estimate the amount of each food and beverage item consumed (Gibson and Ferguson, 1999). Portion sizes may be presented in household measures such as “cup,” “plate,” etc., or even derived at a later date from photographs of household utensils (Gibson, 2005). Participants are also asked to list all ingredients in any consumed mixed dishes (Gibson, 2005). During the final fourth pass, the 24-hour recall is
reviewed to confirm that all consumed food items are included and have been recorded accurately (Gibson and Ferguson, 1999).

The strength of this method for assessing actual dietary intake is evidenced by its use in several national and other large-scale nutrition surveys such as NHANES and CSFII (NCHS, 1994; USDA, 1998). However, its success and efficacy are highly contingent upon the respondent’s memory in recalling consumed food and beverage items, his or her ability to accurately quantify consumed portion sizes, and the interviewer’s own ability to collect all necessary data (Gibson, 2005). Furthermore, a single 24-hour diet recall cannot be used to make inferences about the typical dietary or nutritional intake of a community or an individual (Gibson, 2005). Single-day recalls collected from many different respondents can offer valid dietary assessments of a community, but making assessments about an individual requires the interviewer to employ a slightly different approach known as the “repeated 24-hour recall method” (Gibson, 2005).

**Repeated 24-hour recall method**

Logistically, the repeated 24-hour recall method is quite similar to the 24-hour recall method, except that it collects multiple recalls from the same respondent over a longer period of time. These recalls should optimally be obtained over a period of one year, in order to capture any long-term or seasonal diet variation (Gibson, 2005). Of course, food intake can also vary on a day-to-day basis, so it is recommended that recalls are taken on non-consecutive days (Gibson, 2005). Collectively, repeated 24-hour recalls allow the researcher to better gauge the usual diet and nutritional intake of an individual. Several implications can be drawn from this type of data,
as dietary and nutritional intake are early signs for risk of under- or over-nutrition, among many other health issues.

**Estimated food record**

Another strategy for measuring dietary intake is the “estimated food record.” Similar to the 24-hour recall methods, respondents are asked to record and give detailed descriptions of all foods and beverages consumed, and their method of preparation, within a certain time period (this is usually defined by the investigator) (Gibson, 2005). However, there is some deviation in terms of how to measure or determine their consumed quantities. Using standard household utensils like measuring cups and spoons is optimal, although in some cases it may be necessary to measure with a ruler (such as for meat) or counts (such as for eggs or fruits) (Gibson, 2005). The procedure is more arduous for mixed dishes: All raw ingredients and their quantities should be recorded, the completed dish must be weighed, and then the amount consumed by the respondent must also be weighed (Gibson, 2005). Finally, the investigator must convert all portion sizes from their volumes listed in the food record to their respective weight equivalents (Gibson and Ferguson, 1999).

The estimated food record aims to record consumed portion sizes more accurately than other approaches, but it does have its shortcomings. Depending on the study, much of this accuracy depends on the respondents themselves, as they or a parent/caretaker may be responsible for completing the entire food record when the investigator is not present (Gibson, 2005). Although the investigator assumes a more passive role during this data collection phase, he or she is also subject to err during the subsequent process of portion size conversion. Nevertheless, this method is appealing because its parameters can be flexed to accommodate a
several different research objectives. For example, the number of estimated food records needed from each respondent may be adjusted to obtain and assess average food intake from an individual or a larger group.

**Weighed food record**

According to Gibson, the “weighed food record” is the most precise approach for estimating typical food and nutrient consumption patterns of individuals (2005). In practice, the respondent or his or her parent/caretaker weighs all foods and beverages consumed within a specified time frame (Gibson, 2005). Respondents should also record available information about food brands and preparation methods in the food record. When recording mixed dishes, they follow a strict protocol that requires them to describe and weigh all raw ingredients, weigh the final total weight of the mixed dish, and then weigh the actual portion of food consumed (Gibson, 2005).

Numerous factors must come into play to collect accurate weighed food records. Researchers must be mindful of the time of year and number, spacing, and selection of days needed to generate dietary and nutrition profiles within an individual or a community (Bernard, 2006; Gibson, 2005). As with most dietary assessment tools, respondents are trusted to follow the protocol, avoid under- or over-reporting, and keep to their usual eating patterns. The rigor of this particular protocol poses additional challenges though, since the most accurate data tends to come from respondents who are literate, numerate, and highly motivated to participate (Gibson, 2005). Therefore, final study samples and corresponding results or insights may not be fully representative at the community level.
Dietary history

Originally developed in the 1940s, the “dietary history method” is used to characterize typical dietary patterns of individuals over a much longer time period (Burke, 1947). It has since been modified to offer standardized protocols for data collection and probing techniques, while also minimizing interviewer bias (Kohlmeier et al., 1997). This revised method has three components: a 3-day estimated food record, an extensive follow-up interview which obtains information about respondents’ typical dietary intake and patterns over the previous month, and the weighing of portions of commonly eaten foods and beverages (by the interviewer) (van Staveren et al., 1996). Although this method integrates many different phases to gauge longitudinal dietary patterns, it is a rather labor intensive process that does not always produce reliable data. The follow-up interviews can take a long time, and the dietary history often overestimates food and nutrient intakes (Nes et al., 1991; Slattery et al., 2000). Regardless, it continues to be a useful tool for researchers because it mitigates several limitations of the food frequency questionnaire.

Food frequency questionnaire (FFQ)

The main objective of the food frequency questionnaire, or FFQ, is to determine the “frequency with which food items or food groups are consumed during a specified time period” (Gibson, 2005:46). As a self-administered questionnaire, the FFQ is a pre-determined list of various food and beverage items, or simply food groups more generally, that corresponds with several frequency-of-consumption categories (Gibson, 2005). This semi-quantitative approach makes it easier to predict intake of nutrients, such as Vitamin C intake from frequency of consumption of fresh fruits or calcium intake from consumed dairy products (Barr et al., 2001;
Tsugane et al., 1998). It is also a popular method because it poses minimal burden to respondents (as it only takes about fifteen to thirty minutes to fill out), is relatively easy to administer, and has a streamlined procedure for data processing (Gibson, 2005). However, the structured nature of the questionnaire may not fully capture diet variability, and its validity for assessing dietary patterns in the remote past has not yet been confirmed (Gibson, 2005).

**Summation**

Several dietary assessment tools can be used to measure and describe nutrient consumption and eating patterns. Depending on the study, they may be crucial for examining either short-term or longitudinal dietary trends, within an individual, household, community, or larger region. The most common limitation among these approaches is that they are often subject to recall bias with errors of omission and over- and under-reporting. The collection of accurate dietary assessments also rides on the investigator; for choosing the most appropriate method given the study goal(s) and study sample, and for developing or facilitating a standardized protocol for data collection and entry. In light of these caveats, the utility of dietary assessment is anchored in its potential to illuminate nutritional and epidemiological trends across multiples scales. With derived nutrient intake data and biomarker data, dietary assessments can help to identify communities at risk for dual nutritional burden and offer insights for alleviating related health disparities.
CHAPTER 3: STUDY MATERIALS AND METHODS

**General study description**

This study is derived from an NSF-funded research project (BCS 0822967) investigating the impacts of market integration on the health and livelihoods of indigenous groups living in the Napo, Orenella, and Sucumbios provinces of the Northern Ecuadorian Amazon. This northern region is a hotspot of biodiversity, but is continually threatened by increased rates of deforestation (Mejía and Pacheco, 2014). Like many other parts of the Amazon Basin, it is inhabited by numerous indigenous peoples of various population sizes, languages, subsistence practices, and social and cultural customs (Lu, 2007). This project collaborated with five indigenous groups, the Cofán, Huaorani, Kichwa, Secoya, and Shuar, with eight participating communities total. Within Lu and Sorensen’s larger project, a sample of 311 adults aged 18 years and older was recruited to record consumed food and beverage items (n=4204) from repeated 24-hour diet recalls between February and November of 2009. Cofán participants were from Záballo (n=72), Huaorani from Gareno (n=28) and Quehuereono (n=42), Kichwa from Pachacutik (n=18), Pastaza (n=24), and Pilchi (n=201), Secoya from Sehuaya (n=14), and Shuar from Tiguano (n=50). Repeated 24-hour diet recalls were collected from each participant between one and four times, with an average of two times per person for the total sample. For the purposes of this study, the repeated 24-hour diet recalls serve as a tool for assessing cross-cultural dietary composition patterns and variation.
Sample demographics

To better understand the dietary data collected in this study, it is essential to contextualize its participants. In this case, it is important to examine how Cofán, Huaorani, Kichwa, Secoya, and Shuar lived when this study took place, and the variation within and between these indigenous groups and communities. Dispersed across five settlements, roughly 500 Cofán, or A’i, lived in Ecuador at the time of the study (Houck et al., 2013). Like many other indigenous groups living in the Amazon Basin, Cofán have been forced to adapt to the increasing presence of outsiders and their activities. They have been displaced at least twice during the past century due to infringing commercial endeavors like petroleum extraction (Valdivia, 2005). Since their most recent relocation in the late 1960s, they have maintained minimal contact with outsiders, although some communities have begun to engage in ecotourism and other wildlife monitoring programs (Valdivia, 2005). Our participating community, Zábalo, reflects these trends, as it is far from market towns and only accessible by a lengthy boat ride.

As of 2009, Stephen Beckerman et al. estimate that 2,000 Huaorani, or Waorani, inhabit the Ecuadorian Amazon. Despite their long history of sustained contact with outsiders, they have been able to occupy and utilize a large amount of land and resources (Beckerman, 2009). Since they are spread across sixty communities, characteristics of the settlements can look very different. For instance, Quehuereono is only accessible by foot, whereas Gareno can be reached by road. Furthermore, Quehuereono has begun to tap into the ecotourism industry, whereas some residents in Gareno participate in unskilled wage labor at neighboring petroleum extraction sites (Houck et al., 2013).
Kichwa, or Quechua, are the most populous Amazonian indigenous group in Ecuador, as their population was last estimated at 60,000 (Irvine, 2000). They too have a very long history with outsiders, which was initiated by the arrival of Spanish missionaries. Many Kichwa communities are closer to market towns than their indigenous counterparts. During this study, Pilchi was only accessible by boat, but Pachacutik and Pastaza residents had access to roads and buses which lead to Lago Agrío, an epicenter for market activity (Houck et al., 2013). Electricity was limited but available in communities that had solar panels (Houck et al., 2013).

Roughly 400 Secoya live in Ecuador, occupying three closely-spaced settlements (Valdivia, 2005). For the past couple decades, they have been repeatedly targeted by Occidental Petroleum, which has sought to gain access to and develop land in Secoya territory (Valdivia, 2005). Their relationship has been further soured by contamination of the Aguarico River, the Secoya’s main water source (Smith, 1998). This hostile dynamic has encouraged Secoya to be actively involved in ecotourism, as this strategy has allowed them to preserve land claims (Smith, 1998; Valdivia, 2005). Communities are therefore reasonably accessible, as contact with outsiders has become more frequent (Valdivia, 2005).

Shuar are the second largest indigenous group in Ecuador, with a population of about 40,000 (Houck et al., 2013). Continuous contact with outsiders since the early twentieth century has motivated them to adopt new strategies for securing land claims (Houck et al., 2013). For example, they reorganized their living patterns from that of dispersed households to nuclear communities and began to partake in cattle production (Houck et al., 2013; Rudel et al., 2002). Tiguano, the study community, does not fully reflect this lifestyle, as its distance from the major port city of Coca may be a barrier for some outside contact.
Ethics and confidentiality

The research project was approved by the Office of Human Research Ethics at the University of North Carolina at Chapel Hill, appropriate indigenous federations, and participating indigenous groups and communities. Participants were asked to provide name, age, sex, and community of membership for classification purposes. Each participant was then assigned an identification number to ensure identity confidentiality and anonymity. The identification numbers were used to link each participant’s recorded data across all documents in the data set. All data collected from this study were stored on password-protected laptops and computers, and were shared only with other members of the research team through private, password-protected online servers.

Data collection

Trained research assistants visited each of the eight communities to collect and record repeated 24-hour recalls from study participants. Each individual was asked to provide information about consumed food and beverage items, quantities/serving sizes, and the time at which food and beverage items were consumed. Food and beverage quantities were expressed as numeric counts, metric measures (in centimeters, grams, or milliliters), or general serving size (plate, glass, etc.), and, in some cases, photographs of foods and beverages were taken to help the on-site investigator determine consumed portions. Data was then entered and compiled into a master Microsoft Excel spreadsheet, which contained participant identification numbers, community affiliations, date of diet recall, time of diet recall, foods and beverages consumed, and quantities of consumed foods and beverages.
Data cleaning and analysis

The data set of repeated 24-hour recalls was cleaned in a copy of the original master spreadsheet in Microsoft Excel. To better organize the data, recorded food and beverage items were broken down into the following categories: primary food or beverage item consumed, secondary characteristics of the primary food or beverage item (such as flavor or variety), and preparation method. Food and beverage items were then edited and formatted consistently throughout the data set to make a workable template for coding. A separate tab was used to record all listed names for particular food items. Each such food item was designated one name, which was then used to replace synonymous terms in the data set. A new tab was used to create a cleaned food list, which was comprised of 246 items. Entries that did not have a food item recorded (n=5) were omitted from the data set, as well as entries for which an English translation of the food item could not be identified (n=6). Therefore, analyses were only conducted using 4193 of the 4204 total diet logs that were collected from the 311 participants. Additional entries were made to separate original entries that contained multiple (more than one) food and beverage items. This brought the final count of usable entries to a total of 4774 food and beverage items, or lines of data.

Next, food items were assigned to food groups. These food groups were determined by consulting existing literature on Amazonian diet composition (Dufour et al., 2016; Godoy et al., 2002; Leibert et al., 2013). Ultimately, each food/beverage item was assigned to one of ten food groups: alcohol, animal byproduct, domestic meat, forest game, fruit, market food, processed grain, river fish, traditional beverage, and vegetable. Alcohol items include beer and cane alcohol. Animal byproducts include eggs from chickens, and milk and cheese from cattle. Likewise, domestic meat mostly comes from chicken and cattle. Forest game animals namely
included armadillo, birds, capybara, guinea pig, monkey, and turtle. Among the wide variety of forest fruits, the most common are wild species of guava, grapes, oranges, and tomatoes.

Purchased market foods are predominantly canned goods, juice, soda, and sweets like cookies and candy. Processed grains consist of bread, noodles, oats, rice, and tortillas. A breadth of local river fish species were caught in nearby rivers and vary by community. Homemade traditional beverages make up roughly one third of items recorded in the data set. They include “chicha,” which is derived from either fermented or un-fermented plantains (although other fruits can be used instead), and “chucula,” which is prepared with ripe plantains, milk, cinnamon, and vanilla.

The most frequently eaten vegetables are cassava and plantains, followed by beans and onions. Although this study collaborates with a small sample of indigenous groups, the reported food groups are fairly representative of the Amazonian diet and are consistent with food groups used in several recent publications (see Table 1). Finally, each food group was assigned to one of three food source categories: forest, market, and domestic.

<table>
<thead>
<tr>
<th>FOOD GROUP</th>
<th>KEY FOODS</th>
<th>REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>beer, cane alcohol</td>
<td>*Alcohol is its own food group because consumption is noteworthy in the sample.</td>
</tr>
<tr>
<td>Animal byproduct</td>
<td>chicken eggs, milk, cheese</td>
<td>Godoy et al. (2002)</td>
</tr>
<tr>
<td>Domestic meat</td>
<td>chicken, cattle</td>
<td>Godoy et al. (2002)</td>
</tr>
<tr>
<td>Forest game</td>
<td>armadillo, birds, capybara, guinea pig, monkey, turtle</td>
<td>Dufour et al. (2016); Godoy et al. (2002)</td>
</tr>
<tr>
<td>Forest fruit</td>
<td>guava, grapes, oranges, tomatoes</td>
<td>Dufour et al. (2016); Godoy et al. (2002)</td>
</tr>
<tr>
<td>Market food</td>
<td>canned goods, juice, soda, cookies, candy</td>
<td>Godoy et al. (2002); Leibert et al. (2013)</td>
</tr>
<tr>
<td>Processed grain</td>
<td>bread, noodles, oats, rice, tortillas</td>
<td>Godoy et al. (2002); Leibert et al. (2013)</td>
</tr>
<tr>
<td>River fish</td>
<td>species vary by community</td>
<td>Dufour et al. (2016); Godoy et al. (2002)</td>
</tr>
</tbody>
</table>
Traditional beverage | chicha, chucula | similar to “cultigens” in Dufour et al. (2016)
Vegetable | beans, cassava, onions | Leibert et al. (2013)

The cleaned data set was imported into the statistical computer coding package “R” for statistical analyses. Frequency tables and percentages were generated to assess diet composition of the sample and each community (Ware et al., 2013). Food groups were also collapsed into food source categories to compare diet composition of domestic, forest, and market food items across communities. Pearson’s Chi Square tests were run to determine significant variation in consumption of food sources within the entire sample and between communities (Bernard, 2006; Marius Marusteri and Bacarea, 2010).
CHAPTER 4: RESULTS AND DISCUSSION

Results

The cleaned food list affords several interesting insights about diet composition in the study sample as a whole. It indicates that indigenous communities continue to have access to a variety of forest game (n=22), fruits (n=22), river fish (n=23), and vegetables (n=40) native to the region (see Table 1). Consumed non-alcoholic traditional beverages (n=30) primarily consist of tea and variations of “chucula” and “chicha,” in keeping with local foodways. Communities also prepare many variations of traditional soups and stews from combinations of meat, river fish, vegetables, and processed grains (on occasion). These findings are consistent with the conventional low-calorie, plant-based Amazonian diet. Although native foods are diverse across the data set, the variety of non-indigenous food items is also increasing, specifically ready-to-eat market foods (n=57) and processed grains (n=28).

Table 1. Composition of food items list. N indicates the number of different types of food items reported per food group.

<table>
<thead>
<tr>
<th>FOOD GROUP</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>7</td>
</tr>
<tr>
<td>Animal byproduct</td>
<td>7</td>
</tr>
<tr>
<td>Domestic meat</td>
<td>10</td>
</tr>
<tr>
<td>Forest game</td>
<td>22</td>
</tr>
<tr>
<td>Fruit</td>
<td>22</td>
</tr>
<tr>
<td>Market food</td>
<td>57</td>
</tr>
<tr>
<td>Processed grain</td>
<td>28</td>
</tr>
<tr>
<td>River fish</td>
<td>23</td>
</tr>
<tr>
<td>Traditional beverage</td>
<td>30</td>
</tr>
<tr>
<td>Vegetable</td>
<td>40</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>246</td>
</tr>
</tbody>
</table>

Table 2. Food group frequency and percent distributions. Frequency and percent represent the total reported number of food items, stratified by food group.

<table>
<thead>
<tr>
<th>FOOD GROUP</th>
<th>FREQUENCY</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable</td>
<td>1194</td>
<td>29.9</td>
</tr>
<tr>
<td>Traditional beverage</td>
<td>1102</td>
<td>27.6</td>
</tr>
<tr>
<td>Processed grain</td>
<td>480</td>
<td>12.0</td>
</tr>
<tr>
<td>River fish</td>
<td>280</td>
<td>7.0</td>
</tr>
<tr>
<td>Market food</td>
<td>238</td>
<td>6.0</td>
</tr>
<tr>
<td>Forest game</td>
<td>225</td>
<td>5.6</td>
</tr>
<tr>
<td>Fruit</td>
<td>220</td>
<td>5.5</td>
</tr>
<tr>
<td>Domestic meat</td>
<td>141</td>
<td>3.5</td>
</tr>
<tr>
<td>Animal byproduct</td>
<td>78</td>
<td>2.0</td>
</tr>
<tr>
<td>Alcohol</td>
<td>36</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3994</td>
<td>100</td>
</tr>
</tbody>
</table>

29
Stratified by food group, an assessment of food frequencies and percentages speaks to these trends. Shown in Table 2, the “average” diet of the study sample is relatively diverse overall. The breakdown of diet by percent indicates that indigenous foods (forest game, fruits, traditional beverages, river fish, and vegetables) account for 75.6% of consumed food and beverage items. Access to and consumption of market (processed) food and beverage items are noteworthy. Ready-to-eat market foods are diverse (n=57) and range across study communities, with the lowest consumption in Zábalo (2.2% of food items) and highest consumption in Tiguano (9.1% of food items) (see Table 3). Market foods comprise 6% of all food items in the data set, which is higher than consumption of both forest game (5.6%) and fruit (5.5%), and slightly lower than river fish (7%). Furthermore, processed seasonings and spices (n=24) are used to prepare or flavor foods and beverages. There is great variation in how frequently they are used across communities though. They were used to prepare only 2.7% of foods in Pastaza, in sharp contrast to 38.6% of foods in Tiguano. Overall, processed seasonings and spices served as ingredients to prepare 19.5% of all recorded food and beverage items. Although this category

<table>
<thead>
<tr>
<th>FOOD GROUP</th>
<th>KICHWA Pachacutik</th>
<th>SHUAR Tiquino</th>
<th>HUAORANI Quehuecono</th>
<th>COFAN Zábaló</th>
<th>SECOYA Sehuya</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>0</td>
<td>1.3</td>
<td>2.8</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Animal byproduct</td>
<td>3.5</td>
<td>3.5</td>
<td>2</td>
<td>1.9</td>
<td>0.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Domestic meat</td>
<td>4.5</td>
<td>1.3</td>
<td>3.5</td>
<td>3.3</td>
<td>2.4</td>
<td>1.7</td>
</tr>
<tr>
<td>Forest game</td>
<td>1</td>
<td>0</td>
<td>5.5</td>
<td>6.3</td>
<td>7.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Fruit</td>
<td>5</td>
<td>1.7</td>
<td>8.9</td>
<td>8</td>
<td>6.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Market food</td>
<td>3.5</td>
<td>3.9</td>
<td>7.3</td>
<td>9.1</td>
<td>8.4</td>
<td>8.1</td>
</tr>
<tr>
<td>Processed grain</td>
<td>9.5</td>
<td>15.2</td>
<td>7.9</td>
<td>24.1</td>
<td>14.1</td>
<td>17.7</td>
</tr>
<tr>
<td>River fish</td>
<td>8</td>
<td>12.5</td>
<td>5.6</td>
<td>6.8</td>
<td>5.4</td>
<td>10.5</td>
</tr>
<tr>
<td>Traditional beverage</td>
<td>36</td>
<td>28.6</td>
<td>23.6</td>
<td>8.9</td>
<td>23.2</td>
<td>21.7</td>
</tr>
<tr>
<td>Vegetable</td>
<td>29</td>
<td>32</td>
<td>32.9</td>
<td>31.4</td>
<td>31.6</td>
<td>30.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Seasoning           | 5.5               | 2.7          | 27.4                | 38.6         | 10.4         | 11.2  |

Table 3. Food group frequencies by percent (%) across communities.
includes some herbs like black pepper, basil, and cinnamon, the majority of seasonings in the data set are either fats/oils (butter and vegetable oil) or processed additives (garlic powder, MSG, refined brown sugar and white sugar, and salt).

Further analyses categorized food groups by their sources, as being either domestic, forest, or market. Domestic food sources include animal byproducts and domestic meat; forest foods include forest game, fruit, river fish, traditional beverages, and vegetables; and market food sources include market foods, processed grains, and processed fats/oils, seasonings, and additives. Alcohol was omitted since sources could not be easily deduced. The cross-cultural distribution of market, forest, and domestic foods shows that forest foods comprise a large proportion of the indigenous diet, ranging from 44.4% (Tiguano) to 74.1% (Sehuaya) (see Figure 2).

Market foods are prevalent in all study communities, ranging from 23.3% (Zábalo) to 51.9% (Tiguano) of all reported consumed food items. This suggests that indigenous communities are in contact with nearby market towns and that the degree of market integration may continue to increase. The reported consumption of market foods in the sample has several implications for indigenous livelihoods. Trade for or purchase of non-local foodstuffs not only diversify the diet but also minimize the ability and need to hunt, fish, and gather forest foods. This divergence from traditional subsistence strategies is already evident in the Shuar community of Tiguano, where reported number of used/consumed market foods and processed ingredients (n=411) exceeds that of forest and domestic foods (n=330). Market foods are also noticeably high in the Kichwa community of Pilchi (42.2%) and the Huaorani community of Gareno (33.4%). Universally, consumption of domestic foods remains much lower than that of forest and
market foods, although it is unclear if this is indicative of an increase or decrease in agricultural and livestock subsistence.

**Figure 2. Cross-cultural distribution of food sources (domestic, forest, market) as percentages (%).** Percentage for each food source type per community denoted in white. Note: This figure includes additional data (processed fats/oils, seasonings, and food additives) for market foods. It does not include data for alcohol.

Pilchi has the highest recorded use of market-sourced foods (42.2%) and the lowest recorded consumption of domestic foods (5.4%) and forest foods (52.4%). Compared to other Kichwa communities in the study, Pilchi has lower consumptions of river fish, processed grains, traditional beverages, and vegetables, and higher consumptions of alcohol, forest game, and ready-to-eat market foods. Both Pilchi and Sehuaya have similar proportions of animal byproducts, forest game, vegetables, and ready-to-eat market foods. However, processed seasonings (fats/oils and food additives) are much more prevalent in Pilchi: They were used to prepare 27.4% of foods, as opposed to only 9.7% in Sehuaya. Unlike Pilchi, people in Sehuaya seem to rely more heavily on forest foods for the bulk of their diet (74.1%) and are less likely to consume foods from domestic sources (1.8%). No alcohol or domestic meat is present in the Sehuaya sample. Perhaps due to location, consumption of river fish is much higher in Sehuaya.
than in Pilchi (+11.3%). These dietary differences are by no means exhaustive, but serve as prime examples for capturing the spectrum of diet composition and variation across indigenous communities living in the Northern Ecuadorian Amazon.

Comparisons made across the eight study communities signify differences for diet variation, both within and between indigenous groups. Pearson’s Chi Square tests show that the proportions of consumed food sources are significant for domestic, forest, and market foods \( (X^2=260.48, p=2.2^{-16}) \) and for forest and market foods \( (X^2=236.69, p=2.2^{-16}) \) for the entire sample. Pearson’s Chi Square tests run with Yates’ continuity correction examined consumption of forest and market foods between communities and indigenous groups. The tests identify statistically significant variation in consumption of forest and market foods for several community dyads (see Table 4). These are represented more succinctly as p-values, which convey the level of significance in variance of diet variation for each community, as it pertains to every other community in the data set. Significant diet variation is found among Kichwa, as evidenced between the communities of Pilchi and Pachacutik \( (p=6.69e^{-6}) \) and Pilchi and Pastaza \( (p=0.0001) \). Variance of all three participating Kichwa communities is also significant \( (p=8.74e^{-8}) \). This is not the case for the Huaorani communities of Quehuerono and Gareno. Consumption of forest and market foods varies between most community dyads. Great variance also persists at the level of indigenous group. After collapsing Kichwa and Huaorani communities, cross-cultural comparisons show significant variation in consumption of forest and market foods (see Table 5). All relationships are significant with the exception of Cofán and Secoya. This could be due to a combination of small sample size, participation of only one community per group, and both community’s relative isolation from outsiders.
Results from the dietary data set have several implications. First, diet composition demonstrates that variation in diet does persist at the community level, and that it can occur between communities that belong to the same indigenous group. Second, the distribution of domestic, forest, and market food items reflect that much of the indigenous diet is comprised of forest foods. Despite this, all study communities consumed market items and some may be replacing traditional food staples with non-local, and often innutritious, foodstuffs from local market towns. Third, the frequencies of consumed market foods, beverages, and ingredients suggest that indigenous communities are vulnerable to changes in diet composition and eating patterns. Lastly, cross-cultural comparisons indicate that communities may be undergoing these changes at different rates or experiencing different stages of transition. For this reason, degree of
market integration across indigenous groups and communities may vary and have adverse effects on diet and nutritional burden.

Discussion

The prevalence of commercial market foods, beverages, and ingredients in the data set suggest that many indigenous communities are exposed to urbanization processes through increased contact with non-local people, products, and activities (Popkin, 1999). In fact, these cross-cultural comparisons are akin to diets seen in other global areas undergoing nutritional and epidemiological transitions (Popkin, 1999). For instance, Leatherman and Goodman observe similar diet trends among indigenous communities in Yucatan, Mexico, where tourism has attracted a series of infrastructure and development projects (2005). They found that the local diet was pervasive with high-sugar, high-fat snack foods such as soda, cookies, candies, and chips (2005). The authors aptly refer to this commercialization of food systems as “Coca-colonization,” as Coca-Cola has emerged as a staple commodity in the region (2005). Although commercial foods comprise a much smaller proportion of the Amazonian diet, longitudinal studies have documented increased consumption of vegetable oils, market meats, refined wheat-based carbohydrates, and simple sugars, and decreased consumption of plant foods among several indigenous groups (Benefice et al., 2007; Dufour et al., 2016; Rosinger et al., 2013; Urlacher et al., 2016). Further, Piperata et al note that the Amazonian diet can change very rapidly in a short period of time, as indicated by their findings that intake of purchased carbohydrates, protein, fat, and total kilocalories increased significantly between 2002-2009 in Ribeirinho communities of Brazil (2011).
The prevalence of nutrient-poor, ready-to-eat market foods and processed seasonings in the dataset suggest risk for dual nutritional burden among indigenous communities if current diet patterns continue (Popkin, 2002). It is crucial to consider the repercussions of this, since rapid urbanization has been linked to negative health outcomes at all stages of the lifespan. Unaccompanied by increase in physical activity, influx of new market foods may increase adult overweight/obesity and associated chronic diseases. Additionally, non-uniform distribution of market foods within households may yield different nutritional and health outcomes by sex and age of household members (Tzioumis and Adair, 2014; Urlacher et al., 2016).

Some of the dietary variation observed in this study may be attributed, in part, to community levels of market integration (Dufour et al., 2016; Houck et al., 2013; Urlacher et al., 2016). During the course of Lu and Sorensen’s research project, household input-output diaries were collected from participating communities to gather information about daily subsistence strategies and activities (Houck et al., 2013). Kichwa and Shuar were found to be the most market-engaged indigenous groups in the sample, as many households reported participating in wage labor and selling agricultural products at markets (Houck et al., 2013). While Secoya try to protect their land claims, occasional run-ins with oil companies may lead to increased exposure to market activities (Valdivia, 2005). Huaorani and Cofán communities remain much more isolated, and contact with outsiders rarely extended beyond the selling of forest goods and wild game to tourists (Houck et al., 2013). Analyses suggest that communities with higher levels of market integration (Shuar and Kichwa) may be at greater immediate risk for dual nutritional burden than less involved communities (Cofán and Huaorani) (Houck et al., 2013). This working hypothesis aligns with results from this study: Diet composition and comparatively high prevalence of imported and processed food/beverage items among participating Kichwa
communities are consistent with known precursors of dietary transition and risk for dual nutritional burden (Popkin, 2002).

**Study limitations and future directions**

There were several limitations in this study. The repeated 24-hour recall method relied on study participants to accurately remember what they consumed and how much they consumed. It was clear from the data set that field assistants did not always adhere to the “four-pass” protocol proposed by Gibson and Ferguson (1999): Numerous recalls contained incomplete or missing data, particularly for food/beverage quantities. Some entries did contain exact measures (in grams, milliliters, or centimeters), but others only recorded subjective estimates, such as “un plato grande” or “un pilche pequeño.” Local dishes were also a bit problematic for analysis because most of them did not have corresponding recipes to reference. Since the total number of individual participants recruited and subsequent recalls collected from each community varied so greatly, dietary consumption patterns and variation reported here may not be fully representative. Additionally, the uneven distribution of recalls across participating communities may not accurately capture diet variation across the wet and dry seasons (Silva *et al.*, 2010; Tanner *et al.*, 2013). Cleaning the raw data set posed the most challenges. The lack of a standard terminology was rampant: Several different names were often ascribed to the same food/beverage item. This was augmented by the fact that several items were identified by their indigenous names rather than their Spanish ones. This made them difficult to track down, if at all. Efforts to standardize the data were further compounded by a myriad of spelling errors and formatting inconsistencies. The process of cleaning, standardizing, and organizing the data set into a workable spreadsheet
for statistical analyses was much more time-consuming than expected. As such, this greatly restricted the scope and focus of the study.

The now workable data set warrants many possibilities for future research. Because diet is linked to nutritional status, these data may be used to predict nutritional change and affiliated health issues. Therefore, the next step of this ongoing study will calculate nutrient intake, as stratified by indigenous group, community, and sex. Nutritional statuses will then be compared with a series of biomarkers collected from the original research project, specifically Body Mass Index (BMI), diastolic and systolic blood pressure, and hemoglobin profiles. These analyses may illuminate risk factors for cardiometabolic and cardiovascular disease later in life, and earlier predictors of dual nutritional burden at the individual, household, and community levels (Milner and Beck, 2012).

Conclusions

The Northern Ecuadorian Amazon has experienced rapid population growth in recent decades, with numerous effects on local biodiversity and communities. Oil extraction, deforestation, infrastructure, and a growing tourism industry continue to pressure many indigenous communities to engage with outsiders and emerging market economies, with serious implications for traditional livelihoods and health. Since accelerated dietary transitions often precede nutritional and epidemiological transitions and dual nutritional burden, this study sought to assess cross-cultural patterns of food consumption and diet composition across eight communities from five indigenous groups. Preliminary assessments of diet composition and variability across participating communities point to urbanization processes as central drivers of diet changes and patterns in the region. The pairing of these findings with future analyses of
nutrient intakes and biomarker profiles will afford greater insights for predicting and alleviating health disparities as stressors of market integration intensify.
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