

Blood Pressure Variation in the Northern Ecuadorian Amazon

A review of significance, risk, and broader application

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Abstract

This biocultural anthropology thesis assesses the anomalies in blood pressure rates of four indigenous Northern Ecuadorian groups utilizing data collected between 2001 and 2014 by UNC-affiliated researchers. It aims to holistically compare the findings of each indigenous group in analysis to that of contemporary health trends in Western industrialized countries like the United States. Overall, the project's objective is to assess and analyze the variations that exist in blood pressure recordings (specifically those drawn in 2009) of the Quichua, Shuar, Cofán, and Huaorani groups related to anthropometric measurements, the environment, and the economy and draw comparisons to standard rates in the United States. It can be concluded that several factors contribute to this notion, including the distinct subsistence practices of each group, the types of economies/consumer markets utilized within each region, the determinant patterns of physical labor as it relates to commercialism, and the governing social perceptions concerning health and wellness. This project offers researchers, biologists, and anthropologists a way to infer further applications of the uses and indications of blood pressure recordings, such as surveying how and why social influences impact biological functions differently in high versus low-developed countries.

Introduction

Blood pressure increases with age in industrialized nations like the United States and other high-income countries. Hypotheses for this phenomenon include unhealthy dietary and physical habits, such as a lack of exercise, high rates of obesity and BMI, and social and environmental stressors. Population-level surveys help to clarify how cultural and social differences lead to variations in health measures, like blood pressure, across geographic regions. Specifically, it is essential to note how age relates to blood pressure increases over the life course. For example, among Americans over forty, systolic pressure (SBP) increases by about 7 millimeters of mercury (mmHg) per decade (Gurven, 2012). In the United States, by age seventy, over three-fourths of adults are diagnosed with high blood pressure (Gurven, 2012). This increase is so common that it is often considered a normal part of aging.

In comparison, blood pressure in groups pursuing a lifestyle of traditional subsistence practices [i.e., hunting, gathering, and foraging] may not show the same increase with age. This contrast in biological aging could be due to the longevity benefits associated with physically demanding jobs involving manual labor and the amount of time allocated to each specific practice. Prior literature has explored this concept and produced evidence that hypertension is more frequent in modern societies practicing industrialized labor than in lower-developed, pre-industrialized countries or regions like those comprising the lower Northern Ecuadorian Amazon (Gurven, 2012).

Context

The four primary indigenous communities of the Ecuadorian Amazon (the Quichua, Shuar, Cofán, and Huaorani) have a unique background and a distinct lifestyle compared to other locations around the world, particularly developed countries. However, there is limited information on the blood pressure rates of these communities, with few studies investigating age-related variations. Blood pressure is a significant indicator of cardiovascular health and is affected by age, lifestyle, genetics, and environmental influences (Thomas, 2022). By researching and understanding the trends in these groups' blood pressure averages and the contrasts that exist between them, potential risk factors can be identified. Such efforts can contribute to reducing the burden of cardiovascular disease and improving the overall health outcomes of these indigenous communities with cross-cultural applications to wider geographic populations.

Purpose Statement

The quantitative descriptive study contained in this thesis investigates the relationship between age and blood pressure among the four primary indigenous groups living in the Northern region of the Ecuadorian Amazon. Using secondary data analysis, this project aimed to determine critical factors contributing to variations in blood pressure in these indigenous groups compared to the standards in Western countries (i.e., the United States).

Research Questions and Hypotheses

The research questions investigated are:

RQ1: What is the effect of age on blood pressure among the four indigenous groups in the Ecuadorian Amazon?

H1₀₁: Age is not a significant predictor of blood pressure among the four indigenous groups.

H1_{a1}: Age is a significant predictor of blood pressure among the four indigenous groups.

RQ2: What is the effect of age on blood pressure by gender among the four indigenous groups in the Ecuadorian Amazon?

H2₀₁: Age is not a significant predictor of blood pressure in the men and women adolescent samples of Ecuadorian Amazon groups.

H2_{a1}: Age is a significant predictor of blood pressure in the men and women adolescent samples of Ecuadorian Amazon groups.

RQ3: Is variation in blood pressure among indigenous groups linked to patterns of time allocation at the group level?

Definition of Key Terms

Anthropometric Factors: Anthropometric factors refer to the measurements of the human body's size, shape, and composition. According to the World Health Organization (WHO), anthropometric measurements include height, weight, body mass index (BMI), waist circumference, and hip circumference (World Health Organization, 2011). These factors are commonly used to assess nutritional status, identify obesity and related health risks, and evaluate physical fitness.

Body Composition: Body composition refers to the different types of tissue that make up a person's body, such as one's percentage of muscle, bone, and fat.

Body Mass Index: BMI measures body fat based on height and weight. It is calculated by dividing weight in kilograms by height in meters squared. According to the World Health Organization, a BMI of 25 or higher is considered overweight, while a BMI of 30 or higher is considered obese (World Health Organization, 2020).

Diastolic Pressure: Diastolic pressure is the pressure in the arteries when the heart is at rest between beats (American Heart Association (n.d.)). It is measured in millimeters of mercury (mmHg) and is the second number in a blood pressure reading.

Hypertension: Hypertension, also known as high blood pressure, is a condition in which the force of blood against the walls of the arteries is too high (Centers for Disease Control and Prevention, 2022). It is defined as having a systolic pressure of 130 mmHg or higher or a diastolic pressure of 80 mmHg or higher.

Suprailiac: Suprailiac is a term used to describe the area above the iliac crest, which is the uppermost part of the pelvic bone. This area is often used in skinfold measurements to estimate an individual's percent of body fat.

Systolic Pressure: Systolic pressure is the pressure in the arteries when the heart beats and pumps blood out (American Heart Association (n.d.)). It is measured in millimeters of mercury (mmHg) and is the first number in a blood pressure reading.

Time Allocation: Time allocation refers to how people spend their time. For example, how much time is spent in active movement versus rest (inactivity).

Waist Circumference: Waist circumference is an anthropometric factor that measures the distance around the smallest part of the natural waist, usually just above the belly button (National Institutes of Health, 2020). According to the National Institutes of Health (NIH), waist circumference is a helpful indicator of abdominal fat and an important predictor of metabolic health. High waist circumference increases the risk of type 2 diabetes, cardiovascular disease, and other obesity-related conditions.

Significance of this Thesis Study

Outlined as follows, the study outcomes of this thesis project have (I) practical, (II) academic research, and (III) social implications:

(I) Practical Implications

The study outcomes of this thesis can help foreign and domestic healthcare professionals design targeted interventions to prevent and manage hypertension among indigenous groups while delivering culturally competent care. The discussion of the findings can guide the development of culturally appropriate health education programs and the training of healthcare workers to deliver sustainable and effective care to indigenous groups. For example, a study by Affriano et al. concluded that environmental contamination and nutritional transition may have greater contributions to the prevalence of hypertension and altered fasting blood sugar than genetic susceptibility (Arrifano, 2018). Assessing the impacts of displacement and ecological alteration for commercial means on the biological functions of indigenous groups can lead to effective management policies for non-communicable diseases in the Amazon.

(II) Academic Research Implications

The analysis, results, and discussion contained in this thesis can contribute to the growing knowledge of the relationship between age and blood pressure rates among indigenous groups and how they differ from industrialized countries. The findings can inform future research on hypertension and other cardiovascular diseases among indigenous communities in the Northern Ecuadorian Amazon and other South American regions. For instance, identifying the influences of demographics, health status, access to healthcare, health education, sanitation, alcohol use, and smoke exposure on health culture among indigenous Amazonian groups can yield a better understanding of potential health-related livelihood outcomes, and how they may evolve. For example, a study by Brierly et al. found that the most impactful contributions to adverse health-related outcomes (including shifts in blood pressure) over the life-course were a lack of access to healthcare and poor levels of health education, which, when taken together, become “key factors rendering isolated people vulnerable to disease” (Brierley, 2013).

(III) Social Implications

This thesis helps to promote recognizing indigenous knowledge, practices, and interactions related to health and well-being, the environment, and the economy. Historically, indigenous groups of the Northern Ecuadorian Amazon have been isolated from Western society. However, in a contemporary context, Western ideas, businesses, and products are infiltrating this region. Prior literature has examined how the lifestyle choices of the lowland peoples within the Amazon are one of the most vital protective factors against hypertension. However, as Western values encroach on traditional societies, they alter the practices that have previously acted as a roadblock to increased blood pressure rates (Millicent, 1990). It is essential to assess the impacts

of foreign economic and social influences on indigenous Amazonian groups, mainly as it concerns long-term health status.

Summary

Few studies have examined the relationship between age-related blood pressure rates within the Quichua, Shuar, Cofán, and Huaorani groups. This lack of research has led to a gap in knowledge regarding trends in blood pressure rates over the life course among members of these four indigenous groups. Notably, this thesis seeks to identify a trend among data collected on blood pressure rates, age, body composition, gender, and time allocation to assess how the environment and economy have played a role in safeguarding these indigenous groups from the standard BP increases experienced over time in Western societies.

Background Information

High Blood Pressure

Hypertension, or high blood pressure, is a severe health risk leading to heart attack, stroke, aneurysm, kidney failure, metabolic syndrome, memory impairment, vision problems, and ultimately death (CDC, 2021). The universally accepted recommendation for combating high blood pressure is to avoid a sedentary lifestyle and consume a healthy diet low in sodium, saturated fats, and refined carbohydrates (CDC, 2021). For an individual diagnosed with hypertension, the heart must work harder to pump blood throughout the body, thus increasing strain and damage on the arteries while compromising other natural biological functions. In turn, this can lead to an acceleration of the aging process and a decrease in one's quality of life and physical function.

Blood Pressure Among Ecuadorian Amazon Communities

Less developed countries like Ecuador are rich in groups referred to as *zero-slope societies* where blood pressure does not annually increase at the same standard rate as in the United States (Ulrich, 2004), (Lu, 2014). These groups have been coined *zero-slope societies* because, upon review of longitudinal data, the population level trends in the annual blood pressure increase tend to be minimal and slightly gradual, with only recently noted variability. Age-related blood pressure increase is a "high priority target for intervention," and conceptualizing the variations between diverse groups (like those comprising the Northern Ecuadorian Amazon) is an integral factor (Gurven, 2012). Thus, the Quichua, Shuar, Cofán, and Huaorani groups have been identified as the focus of contemporary research studies concerning blood pressure and age in the hopes of identifying new intervention strategies.

Industrialized Society and the Market Economy

Industrialized society is one characterized by factories and industrial facilities used to enable the mass production of goods. In an industrialized society, technology and machinery lead to more significant outputs in manufacturing than individual resource labor alone, which helps to support a larger population (Ross, 2023). Industrialized societies also have market economies, sharing a mutually inclusive relationship. However, a market economy can exist in societies that are not industrialized or are at the pre-industrial stage of demographic transition. Within a market economy, supply and demand are regulators that determine the number of the economy's prices, goods, and services (Team, 2023).

The Market Economy and Ecuador

The Quichua, Shuar, Cofán, and Huaorani groups are still largely dependent on hunting, gathering, fishing, and gardening but increasingly engage in wage labor, travel to urban areas, and rely on market goods and foods. Due to the encroachment of external influences seeking resource extraction and economic development within the Amazon, native indigenous groups are experiencing the effects of assimilation into market-based economies. The economy of several indigenous groups is dependent on the biodiversity that comprises the environment. Previously described as one of the world's greatest biodiversity hotspots, the Amazon is experiencing many changes, such as shifting cultivation systems, promoted through "various forms of conservation and development policies and the emergence of new markets for cash crops" (Adams, 2013).

Researchers have indicated that when communities are subjected to involvement in culturally "foreign" market integrations, changes in "well-being, land clearing, ecological knowledge, social relations, use of natural resources, and health among indigenous people" occur (Lu and Sorensen 2014). The impact of an area's adoption of a market economy could worsen

indigenous groups' joint health by disturbing or completely altering traditional subsistence and cultural practices and destroying inter-ethnic group connections.

In a study conducted on the Mura Indians from Amazonia, researchers found that the prevalence of hypertension (and other cardiovascular risk factors such as heart disease) was significantly higher for indigenous people living in urban areas (characterized by practices such as using factory-produced additives in cooking) than those who lived in rural areas. The higher score for the prevalence of hypertension was most likely attributable to adopting habits and lifestyles that were westernized and foreign (De Souza, 2018).

Anthropometric Factors and High Blood Pressure

Anthropometric factors, such as body mass index (BMI), waist circumference, and waist-to-hip ratio (WHR), are closely associated with blood pressure. A meta-analysis conducted by Sun et al. (2021) involving 27,894 participants showed that waist circumference was positively associated with pre-hypertension with an odds ratio (95% confidence intervals) of 1.28 (1.18–1.40) in the younger age cohort and 1.23 (1.15–1.33) in the older age cohort. This association may occur because excess fat around the waist can, in many instances, lead to insulin resistance and a continued gain of adipose tissue resulting in increased blood pressure. Maintaining a healthy body weight, particularly around the waist, can help to reduce the risk of developing high blood pressure. Additionally, one should regularly exercise and eat a balanced diet to maintain a healthy weight.

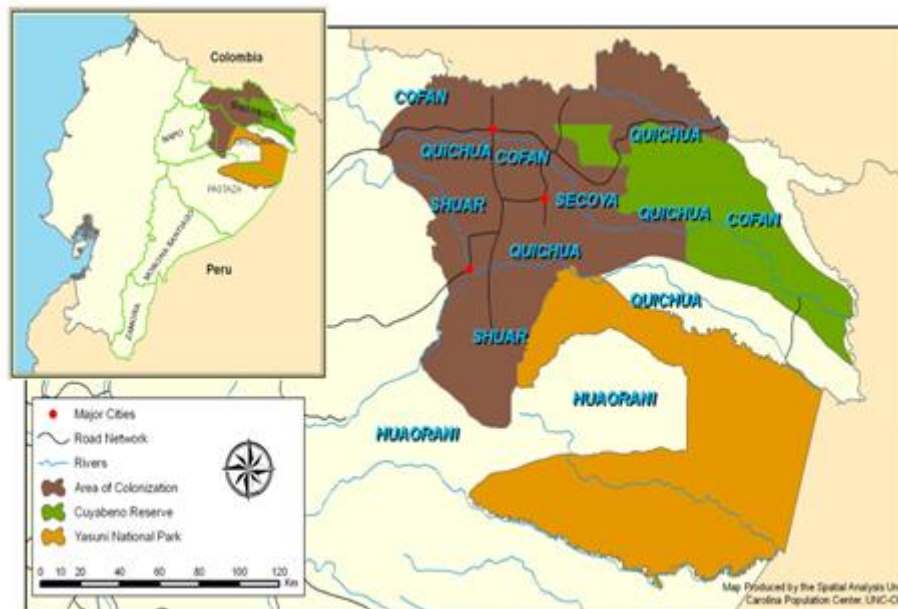
Context of the Ecuadorian Amazon

Ecuador's lowland rainforest (or *Oriente*) is located within the Western Amazon basin. Comprising over 13 million hectares of tropical rainforest, the lowland, rich in vegetation and

biodiversity, is home to the Quichua, Shuar, Cofán, and Huaorani: four indigenous groups that vary in population size, language, and economic practices. As depicted in figure 1, these groups also differ in proximity to major cities, road networks, rivers, and industrialized zones.

Figure 1

Map Marking the Location of the Four Indigenous Groups [the Quichua, Shuar, Cofán, and Huaorani] in the Northern Amazon



Note. Adapted from Lu and Sorensen (2014).

In contrast to the United States, the Amazon is full of traditional communities free of industrialized labor sources. The Amazon, previously void of western influence altogether, differs in values related to health, subsistence practices, and the established relationships between people and the natural environment. For instance, the heavy reliance on the environment associated with producing goods and services using physical labor is a pivotal part of the economy for the Quichua, Shuar, Cofán, and Huaorani groups.

The most populated indigenous group, the Quichua, practices a traditional style of labor exchange, whereby through familial or ritual kinship, physical labor and tasks are completed in

exchange for food. In close geographic proximity to the Quichua is the Shuar, that "since the arrival of the Inca," have "inhabited the upper region of the Amazon Basin" which is now included in Southern Ecuador (Lu, 2014). The Shuar group is characterized by their interactions with the environment, whereby plants, trees, shrubs, and lianas have been utilized to produce necessary goods (ranging from utensils, medicines, cosmetics, construction, tools, and crafts) and even provided as a means for spiritual guidance (Lu, 2014).

The Cofán has a different, more industrialized relationship with the environment. Categorically the most industrialized of the four indigenous groups, the Cofán homeland is referenced to be a "patchwork of oil extraction facilities, boomtowns, colonist fincas, and agricultural plantations" (Lu, 2014). Lastly, the Huaorani, also described as the "least assimilated of Ecuador's indigenous people," grow food and interact with the environment via tribal restriction or grouping (Lu, 2014).

Research Gap

Few studies have examined age-related blood pressure rates among members of the Quichua, Shuar, Cofán, and Huaorani groups leading to a lack of knowledge (and, in some cases confounding analysis between the limited amount of prior research studies) regarding trends in BP rates over the life course.

Methodology

Note. This section provides an overview of the approaches and procedures used in the primary data collection and secondary data analysis process. Explanations are made as to the reasons for choosing particular methodologies and elements of the original research design, such as the selection of the sample. Additionally, this section includes a discussion on the data-gathering techniques and the data analysis plan of this thesis, as well as the restrictions of the primary data collection and ethical considerations involved.

Data Sources and Collection

Data utilized for this thesis study was collected in 2009 as part of an NSF-funded project on market integration and health in the Amazon, with the results published in the American Journal of Human Biology. Researchers from the department of Anthropology at the University of North Carolina at Chapel Hill worked alongside departments from other distinct universities, including but not limited to the Department of Latin American and Latino Studies at the University of California at Santa Cruz, to retrieve data on seven communities.

Measurements

These measurements included recording the body mass index (BMI), triceps skinfolds, bicep skinfolds, systolic and diastolic blood pressure, and supra iliac folds of participants from four indigenous groups (the Quichua, Shuar, Cofán, and Huaorai) residing in five communities. A total number of 126 households and 1205 individuals were studied. The surveyed sample was subdivided into four primary indigenous groups by ethnicity, with their percent of representation distributions in the study as follows: 37.3% of households were Quichua, 24.6% Huaorani, 19.8% Cofán, and 18.3% Shuar.

Time allocation data surveys took place in 2001 and 2009. Five activity types were recorded: social, individual, domestic, subsistence, and commercial. Definitions of each activity type are described below in Table 1.

Table 1

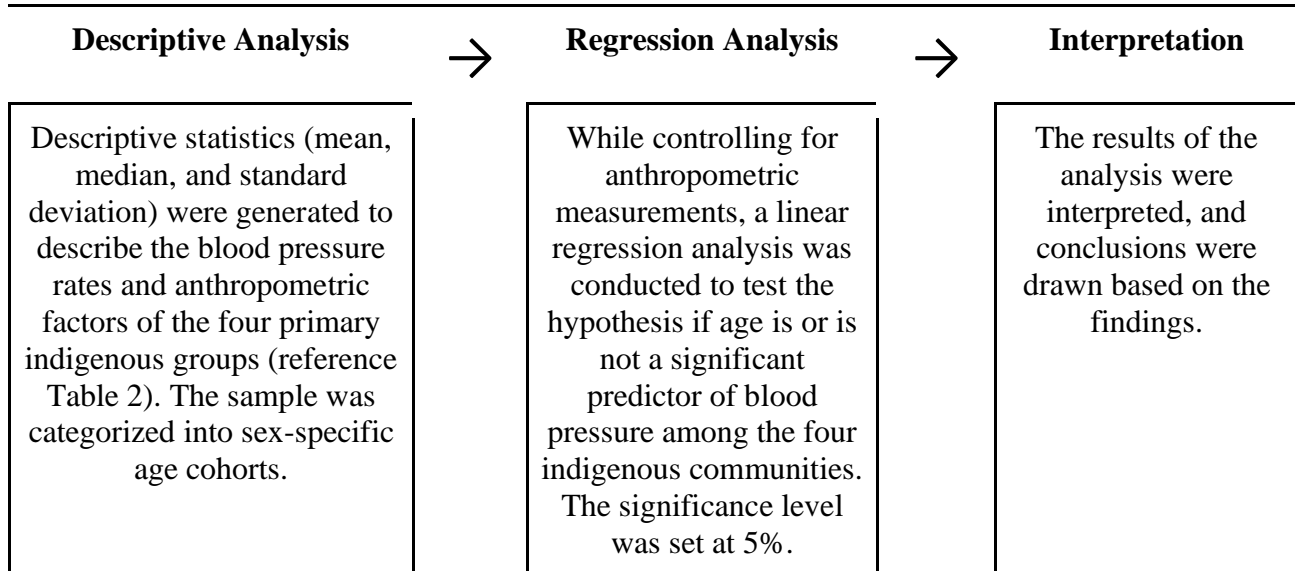
Activity Type and Definition

Activity Type	Definition
Social	Attending school or giving classes, caring for children or other people, attending church, community meetings for communal, political, or ritual purposes, partying, or playing sports
Individual	Dressing, washing, going to the bathroom, sleeping, studying, incurring an illness, or resting
Domestic	Cooking or preparing food, processing food for storage, serving or transporting food, cleaning, collecting water, collecting firewood, or manufacturing or repairing items for one's use
Subsistence	Gardening, hunting and fishing, and handicraft production.
Commercial	Agricultural production, raising animals or cattle for sale, gathering non-timber forest products for sale, manufacturing items for sale, buying, selling items, wage labor, or the cutting and transport or sale of wood.

The study researchers communicated with the indigenous groups in Spanish and were trained on how to distribute, complete, and collect the forms used to record anthropometric measurements to the participant sample. The researchers recorded anthropometric measurements in the following ways: height was measured with a GPM anthropometer, weight was measured with a Seca standing scale, and blood pressure was measured using an aneroid sphygmomanometer with a manually inflated cuff. The published data was supplied for individual use in this thesis project by the Human Biology lab at UNC-Chapel Hill.

Data Analysis

To conduct secondary analysis on the data in the quantitative descriptive section of this thesis project, the following steps were taken:



Justification

Descriptive analysis is an appropriate statistical technique for summarizing and describing the collected data. Descriptive statistics provided a clear picture of the distribution of blood pressure rates and anthropometric factors sourced from the primary data set. Linear regression analysis was essential in determining the contribution of each independent variable to the dependent variable. While controlling for anthropometric factors, analysis enabled testing of the hypothesis if age is a significant predictor of blood pressure among the four indigenous communities. Overall, the use of descriptive and multivariate analysis in this thesis study enabled a comprehensive understanding of the relationship between blood pressure rates and age of the four primary indigenous groups outlined in the results and discussion section.

Results

[Section I: Descriptive Results of Anthropometric Measurements]

Descriptive Statistics Summary

Table 2 displays the descriptive statistics summary of anthropometric measurements for the total sample of 599 individual participants. The average and standard deviation (recorded in millimeters) displayed in Table 2 was used to compare the anthropometric measurements of the four indigenous groups (subcategorized by age and sex) against the average anthropometric measurements within the United States using data reported by the Centers for Disease Control and the National Institute of Health.

Table 2

Summary of Anthropometric Measurements

	Mean	St. Dev.	Median
Adult Men (14 y/o ≥)			
<i>BMI</i>	24.1	2.7	24
<i>TRICEP (mm)</i>	8.6	3.5	8.3
<i>BICEP (mm)</i>	5.2	3.2	4
<i>WAIST CIRCUM (cm)</i>	40	19.1	40.7
<i>SUPRAILLIAC (mm)</i>	10.6	4.8	10.4
<i>SYSTOLIC (mmHg)</i>	114.7	14.4	111
<i>DIASTOLIC (mmHg)</i>	71.5	9.9	70.3
Adult Women (14 y/o ≥)			
<i>BMI</i>	24.3	3.2	23.9
<i>TRICEP (mm)</i>	15.2	5	14.8
<i>BICEP (mm)</i>	11.7	7	9.6
<i>WAIST CIRCUM (cm)</i>	60.1	20.6	62.1
<i>SUPRAILLIAC (mm)</i>	15.7	7.5	14.6
<i>SYSTOLIC (mmHg)</i>	102.1	12.8	100.3
<i>DIASTOLIC (mmHg)</i>	65.6	8.5	64.5

The results provided represent the means, standard deviations, and medians for various measurements for the sex-specific age cohorts. An analytical summary of the results follows:

BMI (Body Mass Index)

BMI, an indicator of body fatness, is calculated by dividing weight (in kilograms) by height (in meters) squared. The BMI results for both men and women of the sample fall within or below the normal U.S. range (~18-25). The mean BMI for adult females is slightly higher than that of adult males.

TRICEP (Triceps skinfold thickness) + BICEP (Biceps skinfold thickness)

These measurements indicate body fat distribution. Generally, adult females have higher triceps and biceps skinfold thickness than adult males, indicating a higher proportion of body fat in females. As seen in Table 2, adult women have a greater average triceps and bicep skinfold thickness than adult men.

WAIST CIRCUM (Waist circumference) + SUPRAILIAC (Suprailiac skinfold thickness)

These measurements also indicate body fat distribution. Adult women of the sample have higher waist circumferences and supra iliac skinfold thickness than adult men, indicating a higher proportion of body fat.

SYSTOLIC (Systolic blood pressure) + DIASTOLIC (Diastolic blood pressure)

Systolic and diastolic blood pressures indicate the pressure of blood on the arterial walls. The mean values for systolic and diastolic blood pressures are within the normal range. However, adult women of the sample have a lower mean systolic and diastolic blood pressure than adult men.

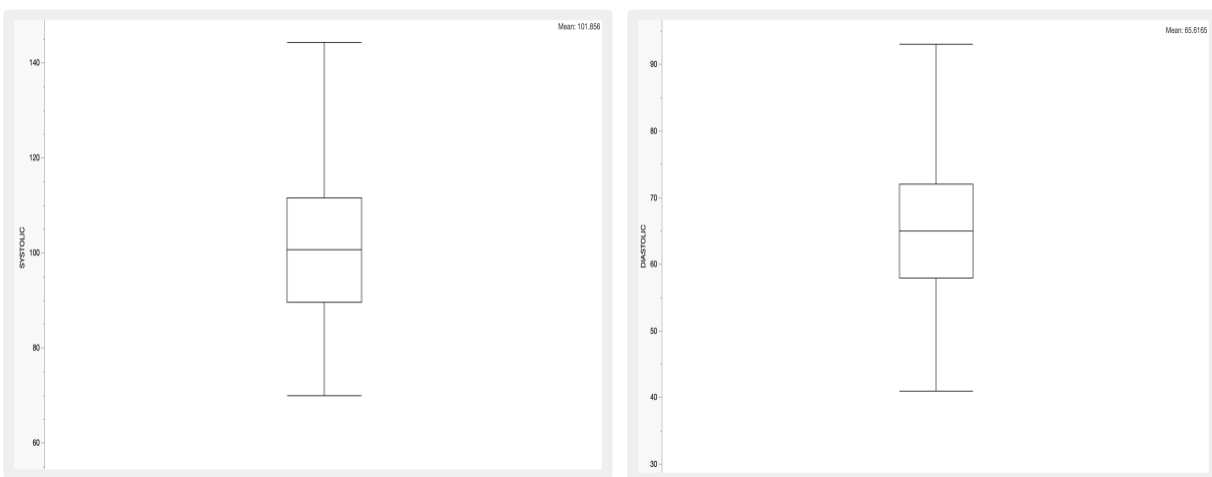
[Section II: Systolic + Diastolic Blood Pressure Results]

Systolic + Diastolic Blood Pressure (Total Sample)

According to the National Institute of Health (NIH), normal (or average) blood pressure is defined as a systolic pressure of less than 120 mmHg and a diastolic pressure of less than 80 mmHg. In figure 2, the data sample had an average systolic pressure of ~102 mmHg and an average diastolic pressure of ~66 mmHg.

Figure 2

Box Plot of the Systolic Pressure (left) and Diastolic Pressure (right)



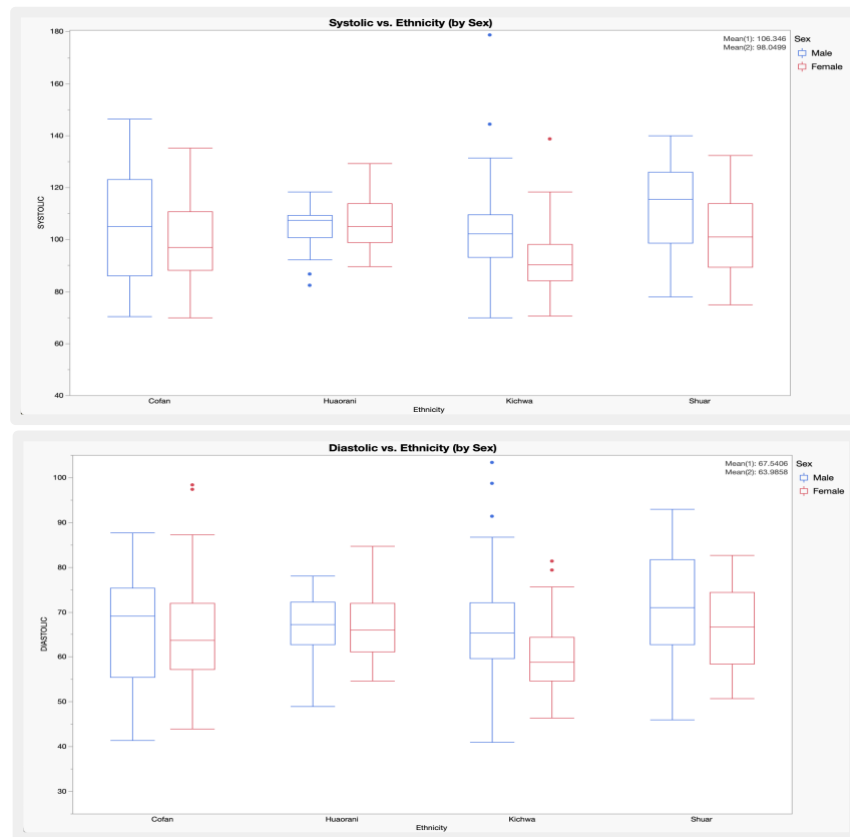
Both the average systolic and diastolic pressure measured below what is deemed *normal* by the NIH. The results indicate that, collectively, the sample for all four indigenous groups reported a lower systolic and diastolic blood pressure reading than the global standard.

Systolic + Diastolic Blood Pressure (Grouped by Sex-Specific and Ethnicity Cohorts)

Figure 3 depicts a box plot graph of the systolic pressure (top) and the diastolic pressure (bottom) measurements grouped into sex-specific ethnicity cohorts. As indicated by the key, the blue boxes represent the men of the sample, and the red boxes represent the women of the sample. The ethnicities of each indigenous group are reported on the X-axis and systolic and diastolic blood pressure are reported on the Y-axis. The men and women are displayed beside one another to demonstrate the variations in systolic and diastolic pressure readings between each ethnic group.

Figure 3

Box Plot Graph of the Systolic and Diastolic Pressure Measurements for the Quichua, Shuar, Cofán, and Huaorani Groups (Ethnicity) Based on Sex



For men (inclusive of all four ethnic groups) there is an average systolic blood pressure of 106 mmHg. For women (inclusive of all four ethnic groups) there is an average systolic blood pressure of 98 mmHg. Men have a higher average systolic blood pressure than the average women (figure 3), thus indicating that sex plays a role in influencing systolic blood pressure. For men (inclusive of all four ethnic groups) there is an average diastolic blood pressure of 67 mmHg. For the women sample (inclusive of all four ethnic groups), there is an average diastolic blood pressure of 63 mmHg. Like systolic blood pressure, the male sample has a higher average

diastolic blood pressure than the average female diastolic blood pressure. Figure 3 indicates that diastolic blood pressure is influenced by sex.

[Section III: Systolic + Diastolic Blood Pressure Results]

Regression Model

Regression models are presented throughout section III to assess the relationship between systolic blood pressure, diastolic blood pressure, and gender. These models reveal that variations exist in the relationship between blood pressure and sex.

Systolic Pressure for Adults by Sex

The model summary in table 3 depicts the statistical results from the prediction model for systolic pressure for the men and women (≥ 14.1 y/o) of all four indigenous groups. The R^2 value of 0.034 for men (upper left quadrant) and 0.009 for women (lower left quadrant) indicates that a considerable proportion of the variance in systolic pressure cannot be explained by the independent variable(s) being considered in the model. Thus, there is no measurable linear effect of age on SBP for men and women according to the trend in the regression model.

Table 3*Model Summary*

Adult Men					
Model	P- Value	R^2	Adjusted R^2	F Statistic	Observations
1	0.077	0.034	0.023	3.19	93
Adult Women					
Model	P-Value	R^2	Adjusted R^2	F Statistic	Observations
1	0.305	0.009	0.0005	1.06	116

Note. ^a Predictors: (Age)

Table 3b*Parameter Estimates*

Adult Men

Model	Estimate	Std. Error	t Ratio	Prob > t
Intercept	107.95	4.09	26.40	<.0001
Age	0.195	0.11	1.79	0.077

Adult Women

Model	Estimate	Std. Error	t Ratio	Prob > t
Intercept	99.188	3.10	31.96	<.0001
Age	0.094	0.091	1.03	0.305

Note. ^a Dependent Variable (DV): Systolic Pressure

The regression coefficients in table 3 did not confirm that age is a significant predictor of systolic pressure in the men and women samples, as shown by $p > 0.05$. These results do not provide sufficient evidence to reject the Null hypothesis that age significantly predicts systolic blood pressure in both adult males and females.

Diastolic Pressure for Adults by gender

Summary table 4 depicts the statistical results from the prediction model for the diastolic pressure for the adult men and women sample (≥ 14.1 y/o) of all four indigenous groups. The R^2 value of 0.027 for adult men (upper left quadrant) and $3.44e-5$ for adult women (lower left quadrant) indicates that a considerable proportion of the variance in diastolic pressure cannot be explained by the independent variable(s) being considered in the model.

Table 4*Model Summary*

Adult Men

Model	P- Value	R²	Adjusted R²	F Statistic	Observations
1	0.112	0.027	0.017	2.564	93

Adult Women

Model	P-Value	R²	Adjusted R²	F Statistic	Observations
1	0.95	3.44e-5	-0.009	0.004	116

Note. ^a Predictors: (Age)

Table 4b*Parameter Estimates*

Adult Men

Model	Estimate	Std. Error	t Ratio	Prob > t
Intercept	67.34	2.81	23.94	<.0001
Age	0.120	0.08	1.60	0.113

Adult Women

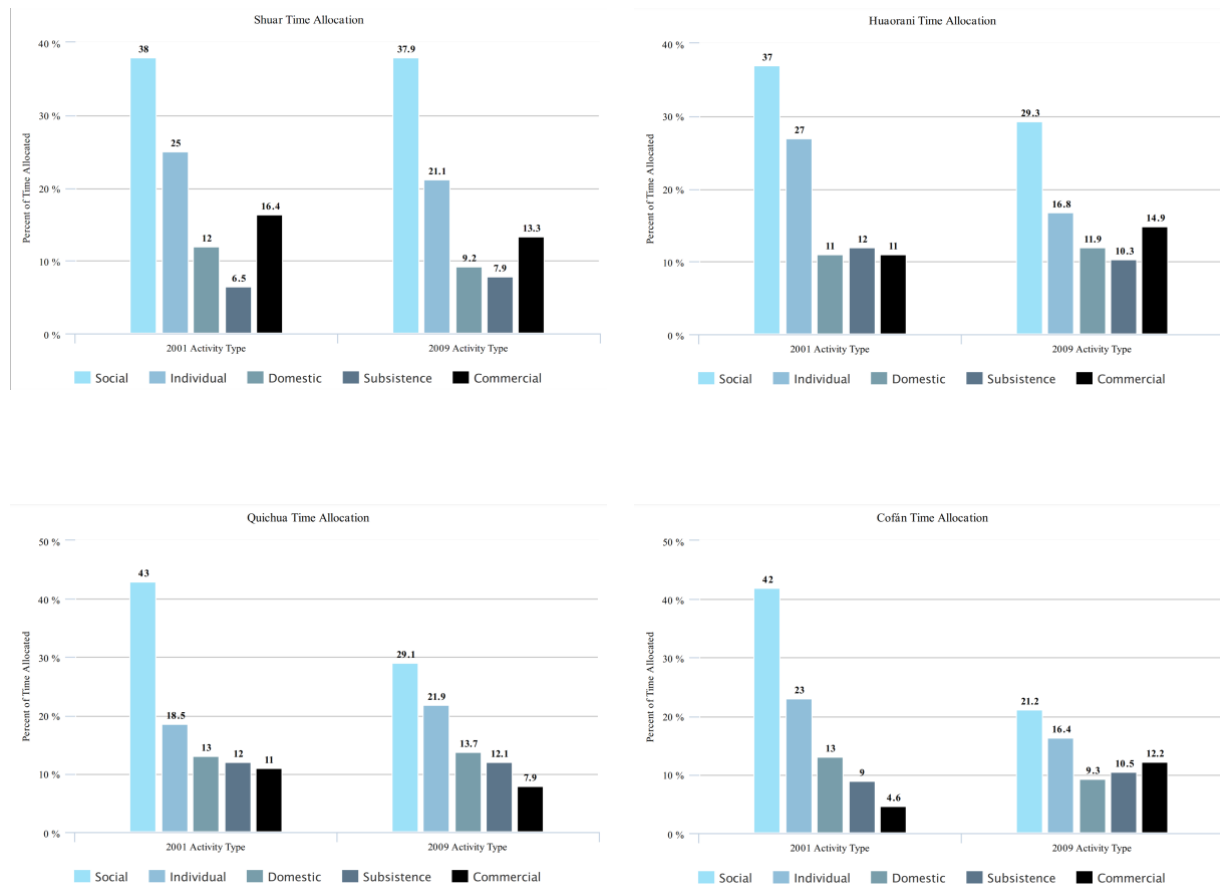
Model	Estimate	Std. Error	t Ratio	Prob > t
Intercept	65.80	2.07	31.76	<.0001
Age	0.004	0.061	-0.06	0.95

Note. ^a Dependent Variable (DV): Diastolic Pressure

The results from the diastolic regression model for adult men was not statistically significant ($F= 2.56$, $p=0.113$), indicating that age is not a significant predictor of diastolic pressure in the sample for adult men. Additionally, the regression model for adult women indicates that age is not a significant predictor of diastolic blood pressure in this sample ($F =$

.004, $p= 0.95$). The regression coefficient table 4b confirmed that age is not a significant predictor of diastolic pressure in the men and women sample, as shown by $p > 0.05$. However, of the observations in this sample, estimates from the regression slope for age in adult men and adult women indicated that a unit increase (one year) in this variable was associated with a 0.12 and 0.004 increase in diastolic blood pressure, respectively. Overall, these results do not provide evidence to reject the Null hypothesis that age does not significantly predict diastolic blood pressure in both adult males and females.

[Section IV: Time Allocation Data Results]

*Time Allocation***Figure 4***Time Allocation Data for Shuar, Huaorani, Quichua, and Cofán Groups recorded in 2001 and 2009**Evaluation of Shuar*

[Trends in domestic and subsistence practices]

Of the most notable changes between 2001 and 2009 for the Shuar group was a decrease in domestic activities which dropped from 12.0% in 2001 to 9.2% in 2009 (for a depression total of 2.8%). Members of the Shuar group spent less time engaging in domestic activities by roughly 0.35% per year if evaluated at an equal distribution level for each intermediate term. The slight

increase in the time allocated to subsistence practices is of significant relation. Between 2001 and 2009, time allocated to subsistence practices increased from 6.5% to 7.9%, respectively. This 1.4% increase may be correlated to the influence of an encroaching market economy (a factor impacting much of Ecuador in recent decades).

Evaluation of the Huaorani

[Trends in social, individual, and commercial practices]

Between 2001 and 2009, time allocated to social activities dropped from 37% to 29.3%, respectively (a total of 7.7% decrease). Members of the Huaorani group spent less time engaging in social roles by roughly 0.96% per year if evaluated at an equal distribution level for each intermediate term. Ultimately, this trend indicates that social engagement was either valued less among members of the Huaorani group or other factors attributed to the significant shift in this specific time allocation. Interestingly, time allocated to individual activities also decreased for members of the Huaorani group, for a total drop of 10.2% (with time allocated to individual activities in 2001 being reported at 27% and in 2009 reported at 16.8%). Therefore, it could be concluded that the change in the time allocated to social activities was not replaced by an increase in the time allocated to individual activities. Typically, social patterns entail transitions between groups favoring social activities over individual activities, or vice versa. However, the data collected between 2001 and 2009 does not indicate a replacement of favorability for one activity type over the other, provided engagement in social and individual activities experienced a substantial decline. However, the time allocated to commercial activities increased by 3.9% from 2001 to 2009. If evaluated at an equal distribution level for each of the eight intermediate terms, engagement in commercial activities would have faced an upward trend of roughly .49% per year.

Evaluation of the Quichua

[Trends in social, individual, and commercial practices]

A 13.9% decrease in the percentage of time allocated to social activities was recorded between 2001 and 2009 for members of the Quichua group. Totaling a roughly 1.74% drop per year (if evaluated at an equal distribution level for each of the eight intermediate terms), the Quichua group ranked second for the most substantial decrease rate in percent time allocated to social activities among all four surveyed groups. Additionally, the percentage of time allocated for commercial activities also experienced a 6.1% decrease (dropping from 11% in 2001 to 7.9% in 2009). However, the percentage of time allocated to individual activities increased by 3.4%.

This data reaffirms the former analysis of the percent statistics and correlations addressed in the Huaorani group section, where the percentage of time allocated to social and individual activities decreased. However, the percentage of time allocated to commercial activities increased from 2001 to 2009 among all three variables.

Evaluation of the Cofán

[Trends in social and subsistence activities]

Time allocated to social activities of members of the Cofán group experienced the greatest shift between 2001 and 2009 of all three other groups. In 2001 the time allocated to social activities by members of the Cofán group was 42%. In 2009 it was recorded at 21.2%, for a total decrease of 20.8% (which, if evaluated at an equal distribution level for each of the eight intermediate terms, is a 2.6% decrease per year). Additionally, the time allocated to subsistence activities increased by 1.5% between 2001 and 2009 (trending upward from 9% to 10.5% in summation).

Conclusion

For the population sample of the four indigenous groups of the Northern Ecuadorian Amazon, age plays a variable role in influencing blood pressure. In the sex-specific group sample for men and women, age was not a significant predictor of systolic pressure or diastolic pressure, and the results of the regression model were not sufficient to reject the null hypothesis **H1₀₁** and **H2₀₁**. However, for the men and women samples, there were slight increases in SBP and DBP if tested at a one-year increase level. Concerning **RQ1** and **RQ2**, the results of the regression analyses carried out for each sex-specific age group led to different outcomes concerning the effect of age on blood pressure. The different implications were also examined through the changes in average systolic and diastolic blood pressure when controlling for specific variables (i.e., Figures 2 and 3).

Ultimately, the results of the regression model for the *systolic blood pressure for adults by gender* did not provide sufficient evidence to reject the Null hypothesis that age does not significantly predict systolic blood pressure in adult men and women. The results from the regression model for the *diastolic blood pressure for adults by gender* did not provide sufficient evidence to reject the Null hypothesis that age does not significantly predict diastolic blood pressure in both adult men and women.

It was determined through analysis of the primary longitudinal data set for time allocation responses that for **RQ3**, variations in blood pressure among indigenous groups could be linked to patterns of time allocation at the group level. However, further investigation and more extensive testing are required.

Discussion

Note. Interpretations in this discussion chapter correspond to the sections of the results.

Limitations

This project was limited in its scope. For instance, the statistics portion of the project was completed using secondary data analysis, which impacted several other areas, including the evaluation and discussion section. Without being the primary data collector, I could not capitalize on personal experiences with the men and women of the four indigenous groups of the Northern Ecuadorian Amazon that contributed to the sample data. Additionally, there was a great amount of missing data entries throughout the primary data set. For example, of the total sample size of 301 men, only 93 participants had usable information for the regression models generated in section III. Similarly, of the total sample size of 298 women, only 116 participants had usable information for the regression models generated in section III.

There was a substantial reliance on prior literature and research to inform my project, which may have contributed to a Western-slanted viewpoint when interpreting the data. If the project could be replicated and repeated, I would attempt to be the primary data collector and account for other variables such as product usage and career types (i.e., recording what kind of foreign products are used within the men and women samples and noting if an individual working for a foreign company such as PetrOriental). Lastly, I would include the juvenile-age cohort and collect data on height and weight as variable factors impacting their blood pressure averages to extend this project's scope.

Section I: Descriptive Results of Anthropometric Measurements

The results of the descriptive statistics summary of anthropometric measurements suggest differences in body composition and blood pressure exist between sex-specific age cohorts. These differences can provide insight into the potential biological risk factors each sex-specific cohort may face based on their average anthropometric recordings.

According to the Centers for Disease Control (CDC), the average adult man and adult women in the United States have a BMI of 26.6 and 26.5, respectively; as reflected by the results in *Section I*, an average adult man and adult woman the four indigenous groups have a BMI of 24.1 and 24.3, respectively. These findings indicate that the body fat percentage of the average indigenous participant is lower than the average body fat percentage in the United States.

Section II: Systolic + Diastolic Blood Pressure Results

For the Cofán ethnicity group, the mean diastolic pressure for sample of men is approximately four mmHg higher than for women (~69 mmHg versus ~64 mmHg), yet men and women each an almost equivalent maximum (87 mmHg versus 86 mmHg). For the minimum, the diastolic pressure for the sample of men reaches slightly lower than the women by around three mmHg (41 mmHg versus 44 mmHg). This finding indicates that of the Cofán ethnicity group participants, there is a greater variation in gender between the minimum average diastolic pressure than the maximum average diastolic pressure. Concerning the health status of members in the Cofán ethnicity group who participated in the original study, there is a greater proportion of men with lower diastolic pressure than women, yet an almost equal number of men and women report the highest average diastolic pressure.

This finding could also indicate several attributing factors, such as collaborative gender roles (i.e., men and women sharing similar, if not the same, subsistence and domestic

responsibilities). Conversely, the Quichua significantly differs in diastolic pressure readings between the men and women samples. Thus, this could be an indication of a more traditional-leaning society that values customary practices that are labor-intensive and demand higher rates of physical work [i.e., they are experiencing the longevity benefits associated with physically demanding jobs involving manual labor].

The sample of men of the Quichua group has a diastolic pressure range that extends from a low of 39 mmHg to a high of almost 87 mmHg. In contrast, the sample for women of the Quichua group has a diastolic pressure range that extends from a low of around 45 mmHg and a high of roughly 75 mmHg. Additionally, the mean diastolic pressure for the women sample for this ethnicity group does not fall within the average marginal range of the male diastolic pressure. A similar finding can be noted for the Shuar group for average diastolic pressure readings for the men and women samples.

For the Huaorani group, the sample for women has a high diastolic pressure range that dramatically exceeds the sample of men of the same group. The Huaorani is the only ethnic group where the diastolic pressure range for the women sample yields a more considerable average window range than the sample for men by about seven mmHg. Nonetheless, the mean diastolic pressure for men is still higher than that of the women for the Huaorani group (like all three other groups), but only slightly by about two mmHg (~67 mmHg to ~64 mmHg).

Of important note is that the minimum, or low, systolic pressure value for both men and women samples of each respective ethnicity is roughly the same. For example, in the Cofán group, the men and women samples have a low range value variation of only one mmHg (i.e., 70 mmHg for men and 69 mmHg for women). The Quichua displays the same pattern in reverse, whereby there is still a value variation of only one mmHg (i.e., 69 mmHg for men and 70 mmHg

for women), except the sample for men extends lower than the women sample. Ultimately, based on the results displayed in figure 3, it can be concluded that blood pressure varies by sex for the collective average SBP and DBP of each indigenous group.

Section IV: Time Allocation Data Results

Subsistence practices play a role in inhibiting or benefiting many innate biological functions related to health and wellness. Historical trends indicate that blood pressure elevation with age is directly impacted by the transition from a society favoring heavy physical and manual labor to one where practices requiring less demand on the body dominate due, in part, to the encroachment of market economy structures. Studying less industrialized groups and communities can help inform researchers, demographers, and scientists alike of the effects of industrialization, economy types, and subsistence preferences on biological shifts in the body.

High-demand labor markets, like the ones in the United States, may include more significant stressors in the workplace environment. Stress has a direct impact on elevating blood pressure. High-stress environments can increase the risk of high blood pressure at an earlier onset age. However, in the case of the four indigenous groups in Northern Amazonia, the high-stress workplace environments that characterize the United States were absent and, therefore, this was not an assessed variable. The Amazon is home to many lower-developed regions, but market economies (along with their expected demands) are becoming all the more popular as industrialized labor forces look to gain capital through the extortion of the region's biodiversity. In summation, using lower-developed regions that share certain commonalities with developed regions, but lack the conditions attributed to drastic biological strain, can inform us of how “advancement” alters our biological processes, particularly related to blood pressure and *zero-slope societies*.

Indigenous groups performing traditional subsistence practices (as determined based on the evaluation of the time allocation charts) as opposed to commercial practices (including activities to meet the demands of the market economy) had lower levels of combined increases in blood pressure across all age cohorts for both the systolic and diastolic average BP readings. For example, between the recordings of time allocation for subsistence practices in 2001 and 2014, the Quichua group had the lowest average systolic and diastolic BP readings of any other group. This indigenous group did not significantly change the amount of time allocated to traditional subsistence practices, which were physically intensive, as there was an increase of just one percent (12% in 2001 versus 12.1% in 2014). Additionally, the averages in BP readings for both men and women participants, collectively, were lower than that of the other genders in any of the three ethnic groups.

Previous studies can help to verify the relationship between biological change and time allocation assessed in this thesis project. For example, a research study by Silva et al. concluded that in an indigenous Brazilian sample, increased Western influence affected female but not male body composition. To understand why this gender disparity occurred, Silva et al. examined the percentage of time allocated to specific activities, finding that blood pressure appears to be affected by seasonal stresses because during periods of environmental change, Caboclo women may be less active (Silva, 2006).

The analysis that follows discusses the implications that may bridge the contrast in blood pressure recordings between each of the four indigenous groups to a specific subsistence practice, the amount of time allocated to each practice(s), and what force the economy may have played in implicating such change.

Shuar:

Members of the Shuar group spent less time engaging in domestic activities by roughly 0.35% per year if evaluated at an equal distribution level for each intermediate term, and increased the amount of time allocated to subsistence practices by 1.4%. The occurrence is interesting, provided the Shuar have been previously characterized as *nomads*. Historically, this ethnic group was known for its successful gardening techniques and interaction with the dense biodiversity of the upper Amazonian basin. The Shuar's skill and knowledge in horticulture may have proven valuable for outside groups looking to profit off of the natural resources in this geographic region. Members of the Shuar community may have altered the value placed on engaging in domestic roles and responsibilities as a way to accommodate the demands of an economic system whereby the production of goods and services for commercial means (another way in which to sustain the familial unit alongside health and wellbeing) required the incorporation of new subsistence practices outside of traditional applications of manufacturing goods for individual use to meet the demands of external market pressures. Additionally, with the influx of outside pressures that might be supplying resources ranging from contemporary equipment to food, the group's domestic activities may have decreased due to their acquired access to modern tools (thus requiring a lower input of physical labor and further altering the elevation of blood pressure as less manual labor was needed). Ultimately, time allocated to subsistence activities would have been required to increase to produce services demanded by a market economy. While situated around protected wilderness areas, the Shuar group is close to five oil wells and zones marked for future development.

Additionally, the Shuar group is located "in oil concession block 14, currently operated by PetrOriental" (Lu and Sorensen 2014). The Shuar group also has the highest average systolic

and diastolic blood pressure levels of the four indigenous study groups among men and women participants. This could reflect how a previously solely nomadic group is experiencing the effects, (biologically), of contributing labor to the energy market as their average blood pressure increases over time.

Huaorani:

For members of the Huaorani group, the time allocated to commercial activities may have only been made possible by the decrease in the time allocated to social and individual activities, directly impacting the collective systolic and diastolic blood pressure of the men and women participants. This hypothesis could be ethnographically tested by assessing a similar situation where one measures how the percentage of time allocated to social activities limits the ability to allocate time to commercial activities. Additionally, one could measure the Huaorani group members' involvement with foreign commerce in the area. Similarly, the same test could be carried out to measure a Huaorani individual's ability to allocate time to individual activities and how this accounts for either the inflation or deflation of the percent time allocated to commercial activities. The mutual exclusivity or inclusivity of testing how much the percent of time allocated to both social and individual activity, together, at the expense of commercial activities could also reaffirm this assessment. By evaluating which specific activities (like attending communal meetings, resting, or producing goods and services), one may identify a pattern of influence and subsequently advance understanding of how favorability of values in time allocation shifts based on various external influences.

Notably, the Huaorani group ranked second for highest average systolic and diastolic blood pressure among men and women participants. The increase in time spent engaging in commercial practices could be a leading indicator of why this group has the second highest

average blood pressure recording per community. When individuals dedicate larger portions of time toward activities that fuel the labor market, thus limiting the amount of time allocated toward non-stress inducing activities that promote individual health and wellbeing (such as resting or engaging with social support networks), blood pressure could rise due to harsh demands on the body.

Quichua:

The Quichua have always been in contact with outside communities since the Spanish Conquest. As a reflection of this, the lowland Amazonian Quichua is also known as the “fully human beings” (Lu and Sorensen 2014). Based on an increase in the percent time allocated to subsistence activities among members of the Shaur, it was inferred that a market economy may have affected the expected social roles, given that time allocated to domestic activities decreased. Thus, it was assessed that a market economy may have also been a determining factor in the push for the Shuar to move further away from traditional practices and ways of life. However, for the Quichua (because there was a decrease in the time allocated to social activities and commercial activities [between 2001 and 2009] and an increase in the time allocated to individual activities), it is inferred that a change in economy type or structure has not had as significant an effect as on the Huaorani group. Subsequently, the Quichua group also had the lowest average systolic and diastolic blood pressure, and the decrease in the time allocated to commercial practices could determine why this occurred. With members of the Quichua group devoting less time toward the production and sale of goods, the collective blood pressure levels remained lower than the average of the three other studied ethnic groups as less market demands were present.

The percent changes in the time allocated to social, individual, and commercial activities of the Quichua group indicates that the demands of the commercial activities favored did not require a decrease in the time allocated to individual activities but may have required a decrease in the time allocated to social activities. Several factors could be responsible for these transitions between 2001 and 2009, including the cultural value placed on satisfying self-care requirements or fulfilling personal wants or needs over engagement in community events with others, traditional practices, or kinship responsibilities. Additionally, the impact of changes in the economy may not have been strong enough to influence the Quichua to shift from a more traditional/regional value-set to one favoring Western values.

Cofán:

The increase in subsistence activities between 2001 and 2009 may have come at the expense of engagement in social activities for the Cofán group. Ultimately, the decrease in participating in community events with others and engaging in events that promote social support came at the expense of increasing time allocated to subsistence activities.

Members of the Cofán group had the widest interval range (from minimum to maximum) in average recorded systolic and diastolic blood pressure which may have occurred due to the increased demands of subsistence labor, and the lack of time allocated to social activities. Perhaps the wide disparity between maximum and minimum average blood pressure could be attributed to some participants still engaging heavily in social activities and others attributing more time to subsistence practices to fulfill the demands of the market economy.

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