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Hypertension Obesity Prediabetes in Nicaragua Group (HOPING),
A Study of Prevalence of Prediabetes, Diabetes, and
Other Risk Factors for Cardiovascular Disease in Los Robles, Nicaragua

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Abstract

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An abstract of
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Abstract

Hypertension Obesity Prediabetes in Nicaragua Group (HOPING), A Study of Prevalence of Prediabetes, Diabetes, and Other Risk Factors for Cardiovascular Disease in Los Robles, Nicaragua

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Aim

To estimate the prevalence of diabetes, prediabetes, hypertension, and obesity in Los Robles, Nicaragua.

Methods

Emory University (Atlanta, GA, USA) and the University of Calgary (Calgary, Canada) combined their studies to recruit 250 subjects through a convenience sample from all 10 neighborhoods in Los Robles, Nicaragua, in order to complete a comprehensive health survey and collect anthropometric measurements, fasting capillary glucose (FCG), and postprandial capillary glucose (PCG) levels on the subjects. Diabetes was defined as the fasting sample value above 125 mg/dl taken prior to consumption of 50g oral glucose drink or the post-challenge sample above 199 mg/dl taken after consumption of 50g oral glucose drink. Prediabetes was defined by two values, either the Impaired Fasting Glucose (IFG) value, which was the fasting sample between 100-125 mg/dl taken prior to consumption of 50g oral glucose drink, or the Impaired Glucose Tolerance (IGT), which was the post-challenge sample between 140-199 mg/dl taken after consumption of 50g oral glucose drink. Obesity was defined using the WHO Body Mass Index (BMI) classifications, identifying underweight as BMI less than 18.5 kg/m^2, normal weight as BMI between 18.5 and 24.9 kg/m^2, overweight as BMI between 25.0 and 29.9 kg/m^2 and obese as BMI greater than or equal to 30.0 kg/m^2. Hypertension was defined using the CDC hypertension guidelines, classifying normal as Systolic Blood Pressure (SBP) between 90-119 mmHg and Diastolic Blood Pressure (DBP) between 60-79 mmHg, pre-hypertension as SBP between 120-139 mmHg or DBP between 80-89 mmHg, stage 1 hypertension as SBP between 140-159 mmHg or DBP between 90-99 mmHg, and stage 2 hypertension as SBP greater than or equal to 160 mmHg or DBP greater than or equal to 100 mmHg. We used SAS software to analyze the means and confidence intervals of the data collected.

Results

The diabetes prevalence calculated from the FCG was 9.4% and from the PCG was 3.62%. The prevalence of prediabetes calculated from FCG was 55.8% and from PCG was 26.2%. The majority of the sample population –almost 67% of total subjects – was either overweight or obese and the hypertension was noted in 4%.

Conclusion

This study measured prevalence of prediabetes, diabetes, obesity, and hypertension in a population that has yet to be studied. The research provides a framework for further research to be done in assessing diabetes and other cardiovascular risk factors in Nicaragua and Latin America.

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Thesis

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Introduction

Primary Objective: Prediabetes and Diabetes Prevalence

Diabetes is a leading chronic disease worldwide and currently 415 million adults have diabetes globally[1]. In recent years, diabetes has become a global epidemic, representing a major cause of morbidity and mortality. The global prevalence of diabetes among adults over 18 years old was 8.5% in 2014[2] and continues to rise, especially in low-income countries. In addition to diabetes prevalence, prediabetes predisposes individuals to higher risk of diabetes with a conversion rate of 5-10%[3].

In Latin America alone, more than 29 million people have diabetes and it is estimated that 48 million people will be affected by the year 2040. Of the 29 million people, about 40% are undiagnosed and are thus at a higher risk of developing serious complications. In 2015, there were 247,000 deaths caused by diabetes in Latin America and 42.7% of them were in people under the age of 60 years old[4].

Specifically, in the country of Nicaragua, there were more than 275,000 people diagnosed with diabetes, 110,000 with undiagnosed diabetes, and diabetes prevalence was 7.7% among adults 20-79 years old in 2015[5]. A study conducted by the Central American Diabetes Initiative (CADI) in Managua, Nicaragua in 2003 found diabetes was prevalent in 9.9% of the population[6]. There are currently no statistics available that reflect the prevalence of prediabetes in Nicaragua.

While many studies have been done regarding global prevalence of diabetes, there is little data available about diabetes prevalence in Latin America and there is no previous study that focused on both prediabetes and diabetes prevalence in the country of Nicaragua. This study collected subjective survey assessment and quantitative data from the community of Los Robles, Nicaragua with a primary objective to identify the prevalence of prediabetes and diabetes among a sample of the population. The goal of focusing on a rural community was intended to reflect the demographic distribution in Nicaragua since the majority of the population lives in rural areas. Providing essential data on a serious chronic disease in a population that has yet to be studied can help us better understand the role of diabetes in this community and launch a framework for implementing interventions in order to diagnose, treat and prevent the disease.

Secondary Objective: Obesity, Diabetes, and Hypertension as Metabolic Risk Factors for Cardiovascular Disease (CVD)

Cardiovascular disease (CVD) is a leading cause of death around the world, with about 17.7 million people dying from CVD globally every year[7]. Research has shown that obesity, diabetes, and hypertension all play significant roles as independent and codependent metabolic risk factors for CVD.

As a metabolic disorder that is reaching epidemic proportions globally, obesity plays a significant role in cardiovascular disease and about 650 million adults are obese globally[8]. While obesity has been studied to be independently associated with new coronary heart disease (CHD) cases, it also negatively affects conventional CVD risk factors, such as diabetes and hypertension[9]. Notably, the MESA (Multi-Ethnic Study of Atherosclerosis) study assessed the association of obesity with CVD and found a strong relationship between obesity and traditional CVD risk factors—a higher prevalence of hypertension, diabetes, and lower levels of HDL cholesterol were observed in the obese group[10] and obesity was associated with higher cardiovascular events due to increased thickness of carotid arteries, increase of coronary calcium, and increased left ventricular mass size[33].

Diabetes as a risk factor for CVD has been studied extensively over the past few decades. The Framingham study investigated the role of diabetes in cardiovascular disease by following three generations from 1948 to 2002[11]. Significant findings of the study included that the incidence of cardiovascular disease among diabetic men was twice that among non-diabetic men while it was three times higher among diabetic women than non-diabetic women. In addition, there was a significant attributable risk ratio of CVD due to diabetes. These data imply that preventing diabetic incidence may in turn reduce CVD risk[12].

Since the Framingham study, many studies have been performed that examined interventions to prevent and/or better manage diabetes. Most notably in prevention, the Diabetes Prevention Program (DPP) study completed in 2002 concluded that structured lifestyle programs that help people with prediabetes to sustainably modify their dietary and exercise patterns was more effective than the drug metformin[13].

In terms of studies addressing people with diabetes, most notably, the Look AHEAD trial[14] focused on whether combined weight reduction and increased physical activity reduced cardiovascular morbidity and mortality[15]. Even though the study was stopped after 9.6 years and did not find a significant difference in cardiovascular event outcomes between the intervention and control groups, there were noted decreases in other important outcomes between the two groups[16]. Quality of life was overall improved due to improved biomarkers of glucose and lipid control, reduced blood pressure[34], thus reducing the need for diabetic, cholesterol and hypertensive medications, reduced sleep apnea[35], less liver fat[36], less depression[37], reduced urinary incontinence[38], less severe kidney disease and reduced retinopathy[39], reduced knee pain[40], improved sexual function[41], reduced inflammation[42], and less overall health costs[43]. While this study provided a strong foundation, the question of the impact of lifestyle modifications, specifically weight loss and increased physical activity, on cardiovascular risk in patients with type 2 diabetes is still being studied.

In addition to obesity and diabetes, hypertension greatly increases an individual's risk to developing cardiovascular disease by two to three times and has been implicated in 35% of all atherosclerotic cardiovascular events[17]. Results from NHANES III study show that the prevalence of hypertension is higher with higher BMI[18], indicating the strong effects that both hypertension and obesity have on increasing risk for CVD.

Out of the notable studies that studied cardiovascular risk factors in Latin America, the Latin American Consortium of Studies in Obesity (LASO) focused on cardiovascular risk factors in eight Latin American and Caribbean countries and found the prevalence of cardiovascular risk factors of those countries to be similar to those in developed countries[19]. In addition, the Cardiovascular Risk Factor Multiple Evaluation in Latin America (CARMELA) study found the prevalence of hypertension to be similar to the global rate in 3 out of the 7 cities studied[20], and a hypertension study in Nicaragua found the prevalence of hypertension to be 22% in 6 Nicaraguan communities[21].

Research shows that major cardiovascular risk factors are highly prevalent in Latin America and this study's secondary objective focused on estimating the prevalence of risk factors for cardiovascular disease, such as obesity, diabetes, and hypertension, in the study population in Nicaragua, and also compared them to regional and global findings. This research provides further data to better understand the independent and codependent relationships between the risk factors for CVD, especially in an understudied rural population.

Materials and Methods

Study Design

This descriptive study contained both quantitative measurements, which consisted of anthropometric and point-of-care capillary blood glucose values for each subject, and a comprehensive survey of each subject. Anthropometric values included height, weight, and waist circumference and blood pressure levels were recorded. The survey included numerous categories of questions based on living conditions, financial and economic means, past medical history, current medical conditions, family dynamics, nutrition, physical activity levels and mental health.

Population

The sample population focused predominately on mothers, aged 18 years or older, in a rural town in northern Nicaragua called Los Robles. The town consists of 10 neighborhoods, 467 homes, 552 families, and 2,113 people, and is located 15 kilometers from the city of Jinotega[22]. We chose the study participants based on the community census report of 10 neighborhoods, on availability, and on willingness to participate. Consecutive houses were visited in each neighborhood until the target sample number of 250 participants was met. Numbers of those approached who declined or were unable to participate were not recorded. Our goal of collecting data from 250 participants was met over a 3-month period from May to July in 2015.

Data Collection

Our group divided into four respective teams consisting of one Brigadista and one graduate student, and each team met individuals in their homes where the comprehensive survey was completed and anthropometric data was collected. Our team consisted of epidemiologists, medical doctors, and public health graduate students from Emory University in Atlanta, GA, USA, as well as a team of anthropologists and graduate students from the University of Calgary in Calgary, Canada. We collaborated to collect survey and quantitative data on heads of households with a focus on diabetes and maternal health. Along with our team, local healthcare workers called Brigadistas helped us and played a significant role in successful participation and survey accuracy by increasing rapport and trust within the community.

The study was approved by the Institutional Review Boards (IRB) of Emory University and the University of Calgary. All respondents gave written informed consent upon participation into the study.

Outcomes Examined

Glucose measurement

Standard measures of diabetes diagnoses, specifically fasting plasma glucose or plasma glucose after a 75g oral glucose tolerance test, were not easily obtainable in the rural setting of the study sample. The nearest laboratory was 20km away, transportation with plasma blood samples was highly challenging, and storage of the samples was difficult. Therefore, we decided to measure capillary blood glucose levels with a hand-held glucometer to capture the prevalence of prediabetes and diabetes. We also used the 50g OGTT instead of 75g due to the availability of the 50g solution, following the guidelines for screening for gestational diabetes. Instead of taking the first sample then having the subject drink 75g glucose solution and wait for 2 hours, these guidelines recommend the subject consume 50g solution and then are retested after 1 hour[50].

Before collecting the blood glucose levels, the subject was asked if they had ever been diagnosed with diabetes. If their response was yes, their fasting capillary glucose level was taken but the oral glucose drink test was not performed and the subsequent postprandial capillary glucose level was not drawn on this subject. If their response was no, the complete screening test was performed. Diabetes was defined based on a combination of self-report and biochemical measures (please see below for definitions).

The team measured the levels and observed compliance to fasting for the hour after consumption of the drink. Prediabetes was defined as impaired fasting glucose and impaired glucose tolerance tests (please see below for definitions).

Measurement of Other CVD Risk Factors

The other cardiovascular disease risk factors examined in this study included hypertension and obesity. The subject was not asked if they had ever been diagnosed with hypertension or had high blood pressure values in the past before blood pressure was taken. Hypertension was measured by taking 3 blood pressures on the same arm, each 5 minutes apart. The results focused on the average of the systolic pressure as well as the average of the diastolic pressure.

Obesity was assessed through waist circumference, weight, and BMI. Waist circumference was measured in inches by using a measuring tape to measure the waist measured at the midpoint between the lower margin of the least palpable rib and the top of the iliac crest of the subject[48] and an average number was calculated of two separate consecutive measurements. Central obesity was defined from waist circumference if the value was greater than 88cm. Weight was measured in kilograms using a standard Seca scale and an average number was calculated of two separate consecutive measurements.

Height was measured in cm, using a standard Seca stadiometer. BMI was measured using the CDC standard calculation of weight in kilograms divided by height in meters squared. Underweight was classified by a low BMI less than 18.5, normal weight was classified by a BMI between 18.5 and 24.9, overweight was classified by a BMI between 25.0 and 29.9 and obesity was classified by a BMI equal to or greater than 30.

<u>Variable Definitions</u>
Age and sex were self-reported and presented in years and by female or male.

Fasting Capillary Glucose (FCG): Sample taken prior to consumption of 50g oral glucose drink
Postprandial Capillary Glucose (PCG): Sample taken post 1 hour of consumption of 50g oral glucose drink
<u>FCG:</u>
Non-Diabetes: Fasting sample below 100 mg/dl taken prior to consumption of 50g oral glucose drink
Impaired Fasting Glucose (IFG): Fasting sample between 100-125 mg/dl taken prior to consumption of 50g oral glucose drink
Diabetes: Fasting sample above 125 mg/dl taken prior to consumption of 50g oral glucose drink
<u>Post-Challenge:</u>
Non-Diabetes: Post-challenge sample below 140 mg/dl taken after consumption of 50g oral glucose drink
Impaired Glucose Tolerance (IGT): Post-challenge sample between 140-199 mg/dl taken after consumption of 50g oral glucose drink
Diabetes: Post-challenge sample above 199 mg/dl taken after consumption of 50g oral glucose drink

<u>BMI</u>
Underweight: <18.5 kg/m^2
Normal weight: 18.5 – 24.9 kg/m^2
Overweight: 25.0 – 29.9 kg/m^2
Obese: ≥30.0 kg/m^2

<u>Hypertension</u>
Normal: Systolic Blood Pressure (SBP) 90-119 mmHg and Diastolic Blood Pressure (DBP) 60-79 mmHg
Pre-hypertension: SBP 120-139 mmHg or DBP 80-89 mmHg
Stage 1 Hypertension: SBP 140-159 mmHg or DBP 90-99 mmHg
Stage 2 Hypertension: SBP ≥160 mmHg or DBP ≥100 mmHg

Analysis Plan
Statistical analyses were done using SAS software (version 9.4, SAS Institute Inc, Cary, NC, USA). The analysis included 250 total subjects, with 224 completing the diabetic screening tests and 240 completing the anthropometric measurements. Descriptive

statistical analyses were used to report on the demographics of the population such as sex, age, and BMI, using proc frequency, proc means, and proc univariate statements. Inferential statistical analyses were used to estimate the glucose, blood pressure, and other measurements, using proc t-test statement in order to assess means and confidence intervals.

We described the prevalence of diabetes and mean levels of blood sugars – both fasting and post-challenge glucose levels. For each test type, we estimated proportions with non-diabetes, impaired fasting glucose or impaired glucose tolerance, and diabetes.

We then estimated prevalence of co-morbid cardiovascular risk factors, namely weight, BMI, waist circumference, and hypertension. Weight is described as a continuous variable and reported in both kilograms and pounds. BMI is presented as a continuous measure and also categorized as underweight, normal weight, overweight, and obese based on the WHO criteria[28]. Waist circumference is reported as a continuous measure and also in categories based on less than and equal to 88cm or greater than 88cm[29]. Blood pressure is reported as a continuous measure and also categorized as proportions with normal, pre-hypertension, stage 1 hypertension, and stage 2 hypertension sub-categories[30].

Results

In Table 1, we describe the demographics of the study population, consisting of gender, age, and BMI. Overall, the sample population consisted of 247 females and 3 males. The mean age was 32.2 years and the mean BMI was 27.9 kg/m^2.

Using FCG, the mean blood glucose level out of the 224 samples was 107.4 mg/dl, falling in the impaired category (100-125 mg/dl). There were 78 (34.8%) of the FCG results that are classified as non-diabetic, with a mean level of 91.4 mg/dl. There were 125 (55.8%) of the FCG results that are classified as impaired, with a mean level of 109.1 mg/dl, and 21 (9.4%) of the FCG results that is classified as diabetic, with a mean level of 156.5 mg/dl.

In the PCG results, the mean blood glucose level out of the 221 samples was 132.3 mg/dl, falling in the non-diabetic category. There were 155 (70.1%) of the PCG results that are classified as non-diabetic, with a mean level of 118.5 mg/dl. There were 58 (26.2%) of the PCG results that are classified as impaired, with a mean level of 158.7 mg/dl, and 8 (3.62%) of the PCG results that are classified as diabetic, with a mean level of 209.7 mg/dl.

Other CVD Risk Factors: BMI and Hypertension

The average BMI of the sample population at 27.9kg/m^2 falls within the overweight category. The majority of the sample population with 164 subjects or 67% of the total subjects is either overweight or obese and 76 subjects or 31% of the total subjects falling within the normal BMI category. The mean waist circumference of the sample population was 92.9cm. The majority of the sample population falls within increased risk category for waist circumference, with 150 subjects or 64% of the total subjects measuring >88cm.

The mean systolic blood pressure of the sample population was 115.3 mmHg and the mean diastolic blood pressure of the sample population was 73.0 mmHg. The sample population is normotensive, with the majority of the sample population falling within the normal blood pressure category, with 150 subjects or 68% of the total subjects with a systolic blood pressure below 120 mmHg and a diastolic blood pressure below 80 mmHg. There were 63 subjects or 28% of the total subjects that fall within the pre-hypertensive category, 6 subjects or 3% of the total subjects that fell within the stage 1 hypertension category, and 3 subjects or 1% of the total subjects that fell within the stage 2 hypertension category.

Discussion

In this study, we measured the prevalence of diabetes from two different lab measurements, FCG and PCG, and the prevalence of prediabetes in Los Robles, Nicaragua. The diabetes prevalence calculated from the FCG at 9.4% is higher than the global rate of 8.5%[23] and the country rate of 7.7%, whereas the rate calculated from the PCG at 3.62% is significantly lower. The major discrepancy between FCG and PCG could be due to limitations in PCG test collection, as stated below, or due to other reasons, such as a pathophysiological dysfunction with the beta cells within this population. Therefore, the discrepancy requires further research.

The prevalence of both types of prediabetes (IFG and IGT) are significantly high—calculated from FCG was 55.8% and from PCG was 26.2%. The prevalence of prediabetes in the US is 37% among adults older than 20 years[24] and the global rate is 7.8% as of 2010[25]. Therefore, this study's FCG rate is significantly higher and the PCG is lower than the US's rate, and both are significantly higher than the global prevalence. If the rate of prediabetes in Nicaragua follows global trends[26], the rate will continue to increase.

The population falling in the obesity sub-category of BMI at 31% is significantly higher than the data in Nicaragua at 22.2%[27] or the data in other countries[28]. WHO's Global Database on BMI shows percentages of populations from numerous countries that fall within the obese category of BMI, and most fall within 10-25%. However, the percentage of those in the obese category in this population is similar to the US population of 36.5%[29]. These numbers suggest that this population could be at a higher risk for developing diabetes, hypertension, and cardiovascular disease due to the high rate of obesity alone. The obesity epidemic needs to be addressed in Nicaragua and around the world by encouraging those with a high BMI to make the necessary lifestyle modifications, most notably increasing physical activity and eating healthier, and to understand the significance that obesity has on diabetes, hypertension, and cardiovascular disease in order to lower their risk.

Surprisingly, while prediabetes, diabetes, and BMI rates seem to be higher in this sample population, the rate of high blood pressure is significantly lower than other populations. Most other countries find rates of 30-50% of adults > 25 years old with high blood pressure[30], whereas this population has <5% rate of high blood pressure, at 4% of population falling within stage 1 or stage 2 hypertension categories. This is also significantly lower than the 22% hypertension prevalence rate found in the study of 6 Nicaraguan communities[31].

Limitations of the study include the female-dominant sample population, data collection resources, monitoring for fasting compliance, selection bias, and misclassification. The first limitation of study participation with an emphasis on females is due to the primary objective of the Calgary team on maternal health. Therefore, study participants were predominantly female in order to meet both primary objectives of both teams in an efficient and productive way. In addition, the men within the community were consistently preoccupied with work during the days when the survey and data collection took place, making it very difficult and unfeasible to use the male population as subjects. Research has shown men to have higher rates than women of heart disease and diabetes whereas women have higher rates of obesity[47]. However, the difference in diabetes prevalence rates between sexes varies by region. While the diabetes prevalence rate is higher in males than females in the US, the rate is higher in females than males in Central and South America[46]. These gender differences can be explained by biological processes, sociocultural factors, environmental exposures, nutritional influences, life styles or stress, genetic and psychosocial factors as well as differing behavioral perspectives on overall health and treatment[45]. Thus, by excluding men from the study, the prevalence rates do not accurately represent the population and may be substantially underestimated.

The second limitation was difficult to avoid as resources and funds were limited in the study. The preferred methods of screening for diabetes could not be completed due to their expensive nature or the inability to store the samples, such as HA1C test or OGTT with 75g glucose solution, which are currently the most accurate screening tests according to the American Diabetes Association guidelines[44]. The nearest laboratory was 20km away, transportation with plasma blood samples was highly challenging, and storage of the samples was difficult. Instead, the study only allowed for FCG before 50g glucose solution consumption and PCG at one hour after 50g glucose solution, similar to gestational diabetes screening. Thus, these screening methods for diabetes may not accurately represent the population and may have underestimated the prevalence rate since it tested the body's response to only 50 grams of glucose solution instead of the recommended 75 grams of glucose solution. Furthermore, point-of-care testing does not accurately reflect systemic glucose levels in patients with poor perfusion[49].

The third limitation of monitoring fasting compliance is a limitation for both samples. The FCG level was not accurately assessed as fasting level since the study team was unable to assess when the subject had last consumed food/beverage. Therefore, the FCG levels may not have been true fasting levels and may have a much larger unknown margin of error. The PCG after taking the glucose drink for one hour is a minor limitation since the team members, including both the students and Brigadistas, were with the subjects during the entirety of the hour. Therefore, the majority of the subjects adhered to fasting during the hour. However, there were a few instances when the subjects were not monitored and perhaps did not fast during the hour. In those cases, the PCG level might be inaccurately higher due to food/beverage intake during the hour. However, the few instances that might have occurred are unlikely to change the prevalence substantially.

The fourth limitation of the study was selection bias of choosing the subjects. The initial goal of the study was to recruit the subjects from random selection. However, once in the field, it was proven to be very difficult to randomly select the subjects. The availability of each subject varied depending on the house and time of day since the teams collected data from 7am to 2pm daily. Therefore, those women who had day jobs, for example the teachers that lived within the community, were unable to participate. In addition, those who were excluded from the study due to declining or being unable to participate were not recorded and not further investigated. Therefore, selection bias makes it difficult to assess if the sample population was an accurate representation of the total population. The prevalence rates could be significantly under or overestimated due to this discrepancy.

The final limitation of the study was misclassification about the hypertension category. The subjects were not asked if they had ever been diagnosed with hypertension or had high blood pressure values in the past before blood pressure was taken. Therefore, the prevalence may be underestimated if there were subjects that had been diagnosed with hypertension and had been taking antihypertensive medications. In addition, white coat hypertension[51] was not taken into account. While three blood pressure levels were performed, the subject could have been anxious temporarily due to the study and the blood pressures recorded may not be the subject's true blood pressure level. Therefore, these discrepancies may have caused the blood pressure levels to be under or overestimated.

The strengths of this study include providing both quantitative data and subjective survey assessments on a population that has yet to be studied regarding diabetes and cardiovascular risk factors. The study captured two different types of diabetes tests, FCG and PCG, and numerous cardiovascular risk factors. Therefore, the comprehensive nature of the data collected is one of the most significant strengths of the study, especially in a country with minimum previous data collected.

Future Directions

This study supports the need for more research to be done in Nicaragua and Latin America on diabetes and cardiovascular risk factors, as well as the importance of including prediabetes numbers in diabetes research. In addition, other data collected from the project needs to be analyzed, especially regarding dietary factors and nutrition, in order to provide a better understanding of the roles that diet, nutrition and other factors play on obesity, hypertension, diabetes, and ultimately cardiovascular disease. The limitations of the study prevent the study from providing an accurate representation of the study population and, therefore, more research needs to be done that captures a more representative distribution of the population. The men of the population need to be included in future studies in order to better represent the study population. In addition, more accurate and up-to-date screening tests for diabetes need to be done, such as the hemoglobin A1C test, and more accurate reporting of already diagnosed hypertension and diabetes among the subjects. In doing so, more credible comparisons can be made between this population and the rest of the country of Nicaragua, the other Latin American countries, and the rest of the world.

This study acts as a foundation for further research regarding prediabetes, diabetes, and cardiovascular risk factors in Latin America and specifically in Nicaragua. It provides evidence that there are significant rates of prediabetes, diabetes, and obesity in Los Robles, Nicaragua, and a more thorough investigation needs to be performed. By collecting a larger sample of quantitative data and subjective survey assessments, the population will be better understood and more credible comparisons can be made between national and global rates. Future research should include linear regression models comparing other risk factors to diabetes and cardiovascular disease as well as a new study using the more accurate screening for diabetes as stated above.

Furthermore, more research will provide a better understanding of the community, especially in the rural areas with limited resources, and the type of interventions that can be implemented to target diabetes, obesity and hypertension. This research will help health organizations, clinics, hospitals, local health departments, as well as diabetes and cardiovascular disease-focused initiatives, such as the Central America Diabetes Initiative (CAMDI)[32], in combatting diabetes and cardiovascular disease within Nicaragua by providing concrete data and statistics to reflect the severity of the diseases and the acute need to act. Together with the leaders in the government, the health organizations can promote a platform to target both diseases and federally funded programs can be implemented. The guidelines issued by the WHO and other leading global health organizations as well as model programs already implemented throughout other countries should be utilized in order to implement successful, effective, and sustainable programs. Since diabetes and cardiovascular disease are leading causes of death globally, it is imperative that the research be completed in the near future in order to diagnose and treat those suffering from the chronic conditions, and to prevent more cases from occurring, especially in rural areas with limited access to healthcare.

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Appendix

Table 1. Subject Demographics

	Overall n=250	
Patient Demographics	**n**	**%**
Female	247	98.8
Male	3	1.2
	Mean	**SD**
Age (years)	32.2	11.1
BMI (kg/m^2)	27.9	5.2

Table 2. Diabetic Measurements

Measurement Blood Glucose	n (%)	Mean	95% CI
FCG (mg/dl)	224	107.4	(102.7-112.0)
PCG (mg/dl)	221	132.3	(128.8-135.9)
FCG:			
Non-Diabetes: <100 (mg/dl)	78 (34.8%)	91.4	(90.1-92.7)
IFG:100-125 (mg/dl)	125 (55.8%)	109.1	(107.9-110.3)
Diabetes: >126 (mg/dl)	21 (9.4%)	156.5	(111.0-202.0)
PCG:			
Non-Diabetes: <140 (mg/dl)	155 (70.1%)	118.5	(116.5-120.5)
IGT:140-199 (mg/dl)	58 (26.2%)	158.7	(154.6-162.8)
Diabetes: >200 (mg/dl)	8 (3.62%)	209.7	(204.9-214.3)

Fasting Capillary Glucose (FCG): Sample taken prior to consumption of 50g oral glucose drink
Postprandial Capillary Glucose (PCG): Sample taken post 1 hour of consumption of 50g oral glucose drink
FCG:
Non-Diabetes: Fasting sample below 100 mg/dl taken prior to consumption of 50g oral glucose drink
Impaired Fasting Glucose (IFG): Fasting sample between 100-125 mg/dl taken prior to consumption of 50g oral glucose drink
Diabetes: Fasting sample above 125 mg/dl taken prior to consumption of 50g oral glucose drink
Post-Challenge:
Non-Diabetes: Post-challenge sample below 140 mg/dl taken after consumption of 50g oral glucose drink
Impaired Glucose Tolerance (IGT): Post-challenge sample between 140-199 mg/dl taken after consumption of 50g oral glucose drink
Diabetes: Post-challenge sample above 199 mg/dl taken after consumption of 50g oral glucose drink

Table 3. CVD Risk Factor Measurements

	n	Mean	95% CI
Weight			
Weight (kgs)	240	65.5	(63.8-67.2)
Weight (lbs)	240	144.0	(140.2-147.7)
BMI (kg/m^2)	240	27.9	(27.2-28.5)
BMI Criteria			
BMI: Underweight (kg/m^2)	3	18.0	(17.2-18.8)
BMI: Normal (kg/m^2)	76	22.9	(22.5-23.3)
BMI: Overweight (kg/m^2)	90	27.7	(27.3-28.0)
BMI: Obese (kg/m^2)	74	33.8	(32.8-34.7)
Waist Circumference			
Waist Circum (cm)	234	92.9	(91.5-94.4)
Waist Circum≤88cm	84	81.3	(80.2-82.3)
Waist Circum>88cm	150	99.5	(98.1-100.9)
	n	**Mean**	**95% CI**
Blood Pressure			
Systolic (mmHg)	240	115.3	(113.4-117.1)
Diastolic (mmHg)	240	73.0	(71.7-74.2)
Hypertension Criteria			
Normal (mmHg)	150	107.4/68.2	(106.2-108.7/ 67.2-69.3)
PreHTN: Total (mmHg)	63	126.5/83.0	(125.2-127.7/ 82.2-83.8)
Stage 1 HTN (mmHg)	6	145.5/92.2	(142.4-148.6/ 90.4-94.0)
Stage 2 HTN (mmHg)	3	187.4/105.3	(133.5-241.4/ 98.3-112.4)

BMI
Underweight: <18.5 kg/m^2
Normal weight: 18.5 – 24.9 kg/m^2
Overweight: 25.0 – 29.9 kg/m^2
Obese: ≥30.0 kg/m^2

Hypertension
Normal: Systolic Blood Pressure (SBP) 90-119 mmHg and Diastolic Blood Pressure (DBP) 60-79 mmHg
Pre-hypertension: SBP 120-139 mmHg or DBP 80-89 mmHg
Stage 1 Hypertension: SBP 140-159 mmHg or DBP 90-99 mmHg
Stage 2 Hypertension: SBP ≥160 mmHg or DBP ≥100 mmHg