Management of Noncommunicable Disease Risk Factors among Venezuelans Affected by the Humanitarian Crisis

HARVARD UNIVERSITY

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DISSERTATION ACCEPTANCE CERTIFICATE

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Committee on Higher Degrees in Population Health Sciences,
have examined a dissertation entitled

"Management of Noncommunicable Disease Risk Factors among Venezuelans Affected by the Humanitarian Crisis"

presented by

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Abstract

Humanitarian crises are increasingly longer in duration and more common. At the end of 2020, over 55 million people were internally displaced worldwide: 48 million due to conflict and violence and 7 million due to natural disasters. Globally, people affected by humanitarian crises are especially vulnerable to exacerbated chronic health conditions due to disrupted health services, irregular medication access, and unpredictable food supplies. As such, humanitarian aid and global health actors have become increasingly concerned with the management of noncommunicable diseases (NCDs) in these widespread and prolonged crises.

Venezuela is a unique case as its nutritional context has changed dramatically in the past 10 years due to political turmoil and massive inflation. Prior to the crisis, the burden of cardiometabolic diseases including type 2 diabetes (T2D), hypertension, and obesity were documented to be increasing over time, particularly in urban areas. Over the past few years, however, the NCD burden has been especially hard to quantify, as the Venezuelan government has stopped publishing national statistics since 2016.

To better understand the prevalence of cardiometabolic diseases on a national scale, a group of Venezuelan researchers conducted the first nationally representative survey of health called EVESCAM (Estudio Venezolano de Salud Cardio-Metabólica) from 2014-2017 and conducted a follow-up study in 2018-2020. My dissertation uses EVESCAM data to document the management of cardiometabolic diseases among Venezuelans affected by the humanitarian crisis who were not displaced. It also seeks to understand how modifiable risk factors may play a

role in management and prevention, to inform future research, interventions, and policy in fragile contexts.

Paper One describes the dietary intake of Venezuelans using baseline EVESCAM measurements (2014-2017). My co-authors and I conducted a survey-weighted, nationally representative analysis of dietary, sociodemographic, and clinical data from Venezuelans ≥20 years of age (n=3,402) to understand the prevalence of risk factors for cardiometabolic diseases in this population. Despite a high prevalence of cardiometabolic diseases, adults in Venezuela had not experienced a nutrition transition as observed elsewhere in Latin America. Dietary diversity was low and traditional foods (e.g., arepas and cheese) were still widely consumed, whereas Western foods (e.g., sugar-sweetened beverages) were consumed infrequently.

Paper Two compares multimorbidity patterns in Venezuela with Mexico and US Hispanics using three nationally representative datasets: baseline EVESCAM (2014-2017), the 2016 Mexican National Health and Nutrition Survey (ENSANUT), and Hispanics in the 2015-2016 and 2017-2018 U.S. National Health and Nutrition Examination Surveys (NHANES). To compare multimorbidity between these three settings, we conducted logistic regression to understand the role of sociobehavioral factors in odds of multimorbidity and visualized patterns of multimorbidity using the prevalence of the most common two- or three-disease combinations in each country. We found that even during a humanitarian crisis, multimorbidity prevalence among Venezuelans in EVESCAM was lower than that of Hispanics in the US NHANES sample.

Paper Three examines changes in diabetes management during the crisis in Venezuela. We first documented the status of type-2 diabetes management in baseline EVESCAM (2014-2017) using the continuum of care framework. We then assessed changes in health system performance over time, from 2014-2017 to 2018-2020. Finally, the association between sociodemographic characteristics and care continuum stage was quantified. Care continua included up to six stages: all diabetes; diagnosed; treated; achieved glycaemic control; achieved blood pressure, cholesterol, and glycaemic control; and achieved aforementioned control plus non-smoking. This study was among the first longitudinal continuum of care analyses for diabetes and documented that while treatment rates declined substantially in Venezuela, management of diabetes was not as severely impacted as expected among individuals in EVESCAM during this humanitarian crisis.

Together, these three papers show a variety of quantitative methods to describe and document the state of NCD care in Venezuela, providing important lessons on how NCD management fared in a unique but generalizable crisis setting. Chapter Five highlights the strengths and limitations of this dissertation, as well as the implications of this work and directions for future research.

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Abbreviations

ABC	HbA_{1c}, Blood Pressure, and Cholesterol
ACVE	Acute Cardiovascular Events
BMI	Body Weight Index
CI	Confidence Interval
DALYs	Disability-Adjusted Life Years
DDS	Dietary Diversity Score
ENSANUT	Encuesta Nacional de Salud y Nutrición
EVESCAM	Estudio Venezolano de Salud Cardio-Metabólica
FPG	Fasting Plasma Glucose
HADS	Hospital Anxiety and Depression Scholar
HbA_{1c}	Hemoglobin A_{1c}
HICs	High Income Countries
LDL	Low-Density Lipoproteins
LMICs	Low- And Middle-Income Countries
MDD-W	Minimum Dietary Diversity-Women
NCD	Noncommunicable Diseases
NHANES	U.S. National Health and Nutrition Examination Surveys
OGTT	Oral Glucose Tolerance Test
OR	Odds Ratio
PHQ-9	Patient Health Questionnaire
RRR	Relative Risk Ratio (RRR)
SE	Standard Error
SES	Socioeconomic Status
T2D	Type 2 Diabetes
WHO	World Health Organization

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Chapter 1: Introduction

NCD Multimorbidity

The epidemiological transition* has led to a substantial increase in the global prevalence of noncommunicable diseases (NCDs), including cardiometabolic diseases such as type 2 diabetes (T2D), and cardiovascular diseases.[1] Though long believed to only affect individuals with high socioeconomic status or individuals in high-income countries (HICs), the NCD epidemic has increasingly spread to lower socioeconomic groups and to low- and middle-income countries (LMICs).[2,3] Moreover, mortality from NCDs is higher at every age category in LMICs than in HICs.[3,4] Key unanswered questions in global NCD epidemiology, particularly in LMICs, relate to multimorbidity and NCDs in humanitarian settings, which are the focus of this dissertation.

Prevalence of multimorbidity, defined as the coexistence of two or more diseases in the same individual, has increased worldwide.[5] Compared with only one illness in isolation, individuals with multimorbidity experience higher disability and mortality, lower self-rated health and quality of life, and more frequent health care utilization.[6] As such, multimorbidity is costly to both patients and the health system, particularly in LMICs.[7] Though NCD research has pivoted towards investigating multimorbidity rather than individual diseases,[8] there remains no consensus on which diseases to include in studies of multimorbidity.[9] Additionally, despite ample evidence for higher multimorbidity prevalence at an earlier onset among individuals with lower socioeconomic status,[10] there are far fewer studies among disadvantaged populations and in low-resource settings, such as LMICs.[11-13] Furthermore, even less evidence exists on

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* The epidemiologic transition to the phenomenon where disease burden and morbidity shifts from largely infectious diseases to NCDs.

multimorbidity in humanitarian settings,[14] with the majority of studies focused on refugees living in host countries.[15-17]

NCD Care in Humanitarian Settings

People affected by humanitarian crises are especially vulnerable to exacerbated chronic health conditions and multimorbidity due to disrupted health services, irregular medication access, and unpredictable food supplies.[14,18] This is particularly concerning given that humanitarian crises are becoming longer in duration. For instance, in 2019, nearly 78% of refugees worldwide were in a protracted situation, defined as more than 25,000 refugees from the same country displaced for at least five years.[19] Such crises are also projected to become more common. At the end of 2020, over 55 million people were internally displaced worldwide: 48 million due to conflict and violence and 7 million due to natural disasters.[20] As such, humanitarian aid and global health actors have become increasingly concerned with the management of NCDs, such as diabetes, in these widespread and prolonged crises.[18,21,22]

As NCD management requires continuous care, it also involves prolonged engagement with the health system.[21] Barriers to NCD management include food insecurity, discontinuity of care, and economic hardship, and these barriers are especially exacerbated in crises. For example, diet quality and diversity have been documented to suffer in crises as carbohydrate-rich foods become relied on for caloric intake.[23]

Living with diabetes, for example, involves continuous medication, glucose monitoring, dietary intervention, health literacy with complex regimens, and regular visits to health facilities.[18,24,25] Additionally, diabetes management requires adherence to medications and glucose self- monitoring, which largely depends on supply and access to appropriate medications, glucose meters, and test strips.[25,26] These barriers introduce a number of challenges to diabetes management in crisis settings, though research in this area remains largely uncharted.

Given the difficulties of conducting data collection in these contexts, only a few studies have quantitatively evaluated changes in disease management among people living with diabetes who remained in their home countries during crises.[26-32] Results of these studies have been mixed: three studies documented that average Hemoglobin A1c (HbA_{1c})[†] increased after exposure to crises[26,28,32]; two studies found HbA_{1c} increased only among those on public insurance[30] or with insulin-dependent diabetes[27]; one study found no changes in mean HbA_{1c}[31]; and another study found a decrease in mean HbA_{1c}.[29] Similar barriers exist for management of cardiovascular disease risk factors, such as dyslipidemia and hypertension.

Venezuela as a Case Study

Venezuela is a unique case as its nutritional context has changed dramatically in the past 10 years due to political turmoil and massive inflation. Venezuela was once known as a flourishing upper-middle income country[33] and the burden of diabetes, hypertension, and obesity were documented to be increasing over time, particularly in urban areas, mirroring the nutritional and epidemiological transitions in neighboring South American countries.[34-36] In the early 2000s, the Venezuelan government augmented primary and chronic care programs through a mission between the Cuban and Venezuelan governments. This campaign, known as *Misión Barrio Adentro,* built numerous primary care centers throughout the country, staffed these centers with Cuban doctors, and provided cost-free diabetes medications, although this program only covered 24% of the population with diabetes.[35,37] Other public services, however, remained highly under-funded and lacked coordination as the majority of people with diabetes received care in public facilities.[35]

[†] HbA1C is a key indicator for glycemic control

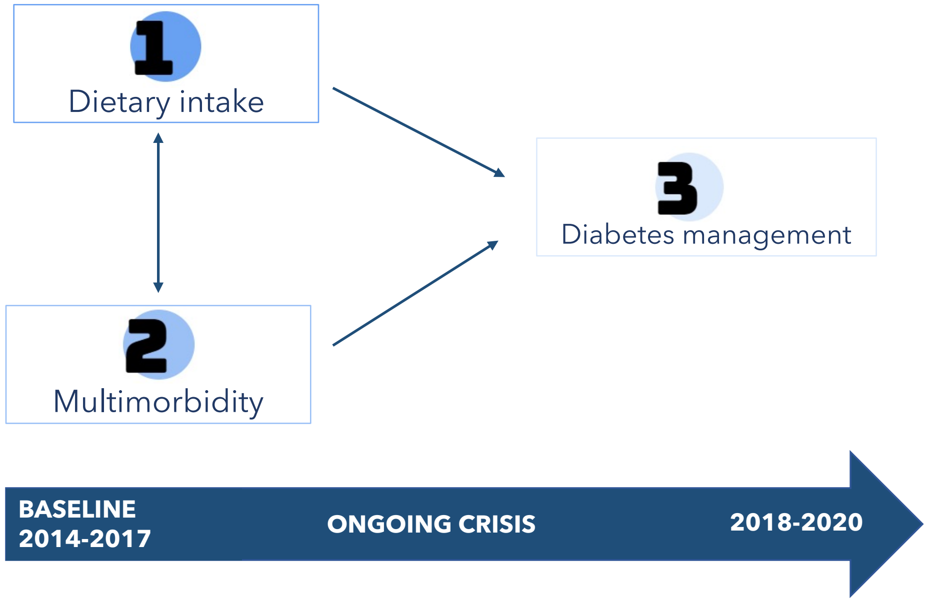
As a result of the gross mismanagement of oil reserves and national funds,[38] hyperinflation and food shortages led to food insecurity and a malnutrition crisis.[39] Over 5 million Venezuelans have emigrated since 2014, mostly to Colombia, Peru, and Brazil, and no estimates exist for the number of internally displaced individuals.[40,41] Moreover, shifts in the NCD burden have been challenging to quantify, as the Venezuelan government stopped publishing national statistics in 2016.[42]

To better understand the prevalence of cardiometabolic diseases on a national scale, a group of Venezuelan researchers conducted the EVESCAM (Estudio Venezolano de Salud Cardio-Metabólica) study from 2014-2020. Details of the study design and sampling strategy have been previously published.[43] Briefly, between July 2014 and January 2017, 3,420 study participants were enrolled using multi-stage stratified random sampling. Thus, at baseline, EVESCAM was nationally representative. The EVESCAM team also conducted follow-up visits for a subset of 35% of participants who were still living in their homes and willing to participate in 2018-2020.

Dissertation Research Questions

In the three chapters that follow, we seek to understand dietary intake at baseline (Paper 1), multimorbidity prevalence at baseline and how it compares to nationally representative estimates from Mexico and the United States (Paper 2), and changes in diabetes management between baseline and follow-up (Paper 3) (**Figure 1.1)**.

Figure 1.1: Dissertation Framework



Chapter Two (Paper One) describes the dietary intake of Venezuelans using baseline EVESCAM measurements (2014-2017). We conduct a survey-weighted, nationally representative analysis of dietary, sociodemographic, and clinical data from Venezuelans ≥20 years of age (n=3,402) to understand the prevalence of risk factors for cardiometabolic diseases in this population. We find that despite a high prevalence of cardiometabolic diseases, adults in Venezuela have not gone through a nutrition transition like observed elsewhere in Latin America. Dietary diversity is low and unhealthy calorie-dense traditional foods (i.e., arepas and cheese) are still widely consumed, whereas unhealthy Western foods (i.e., sugar-sweetened beverages) are consumed infrequently.

Chapter Three (Paper Two) compares multimorbidity patterns among three adult Hispanic populations using three nationally representative datasets: baseline EVESCAM (2014-2017), the 2016 Mexican National Health and Nutrition Survey (ENSANUT), and Hispanics in the 2015-2016 and 2017-2018 U.S. National Health and Nutrition Examination Surveys (NHANES). This survey-weighted study describes multimorbidity in two ways, depending on data availability for a given country. We conduct one analysis that included data from all three countries, multimorbidity was defined as at least two cardiometabolic diseases (obesity, T2D, hypertension, ACVE, high low-density lipoproteins). The second analysis, based among Venezuelans and U.S. Hispanics, defined multimorbidity as at least two cardiometabolic diseases or depression plus one or more cardiometabolic disease. To compare multimorbidity between these three settings, we conduct logistic regression to understand the role of sociobehavioral factors in odds of multimorbidity and visualize patterns of multimorbidity using the prevalence of the most common two- or three-disease combinations for each country. These findings point to a high prevalence of multimorbidity in Venezuela, US Hispanics, and Mexico (ranging from 19-29%). Remarkably, even during a humanitarian crisis, multimorbidity in Venezuela is lower than that of Latinos in the US.

Chapter Four (Paper Three) evaluates the impact of the humanitarian crisis in Venezuela on diabetes management. We first document health system performance for diabetes management in baseline EVESCAM (2014-2017) using the continuum of care framework. We then assess changes in health system performance over time, from 2014-2017 to 2018-2020. Finally, we quantify the association between sociodemographic characteristics and care continuum stage. This is among the first longitudinal continuum of care analyses for diabetes, and documents that while treatment rates have declined substantially in Venezuela, management of diabetes was not as severely impacted as expected during this humanitarian crisis.

Chapter 2: Dietary intake and cardiometabolic risk factors among Venezuelan adults: a nationally representative analysis

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Abstract
Background: Increasing trends in global obesity have been attributed to a nutrition transition where healthy foods are replaced by ultra-processed foods. It remains unknown if a nutrition transition has occurred in Venezuela, a country undergoing a sociopolitical crisis with widespread food shortages.

Methods: We describe dietary intake of Venezuelans from a nationally representative study conducted between 2014 and 2017. We conducted a cross-sectional analysis of dietary, sociodemographic, and clinical data from Venezuelans ≥20 years of age (n=3,420). Dietary intake was assessed using a semi-quantitative food frequency questionnaire. Standardized clinical and anthropometric measurements estimated obesity, type 2 diabetes, and hypertension. A Dietary Diversity Score (DDS) was calculated using an amended Minimum Dietary Diversity for Women score where the range was 0 to 8 food groups, with 8 being the most diverse. Analyses accounted for complex survey design by estimating weighted frequencies of dietary intake and DDS across sociodemographic and cardiometabolic risk-based subgroups.

Results: The prevalence of obesity was 24.6% (95% CI: 21.6-27.7), type 2 diabetes was 13.3% (11.2-15.7), and hypertension was 30.8% (27.7-34.0). Western foods were consumed infrequently. Most frequently consumed foods included coffee, arepas (a salted corn flour cake), and cheese. Mean DDS was 2.3 food groups (Range: 0-8, SE: 0.07) and this score did not vary among subgroups. Men, younger individuals, and those with higher socioeconomic status were more likely to consume red meat and soft drinks once or more weekly. Women and those with higher socioeconomic status were more likely to consume vegetables and cheese once or more daily. Participants with obesity, type 2 diabetes, and hypertension had lower daily intake of red meat and arepas compared to participants without these risk factors.

Conclusions: Despite high prevalence of cardiometabolic risk factors, Venezuelan adults in EVESCAM have not gone through a nutrition transition similar to that observed elsewhere in Latin America. Dietary diversity is low and widely consumed food groups that are considered unhealthy are part of the traditional diet. Future studies are needed in Venezuela using more comprehensive measurements of dietary intake to understand the effect of the sociopolitical crisis on dietary patterns and cardiometabolic risk factors.

Introduction

The relationship between suboptimal dietary intake and noncommunicable diseases (NCDs) is well-established. In 2017, 11 million deaths and 255 million disability-adjusted life years (DALYs) were attributable to dietary risk factors, a considerable increase from an estimated 8 million deaths and 184 DALYs in 1990.[44] Concurrently, the global prevalence of obesity, as well as related cardiometabolic diseases such as type 2 diabetes (T2D) and hypertension, increased substantially over the past 40 years.[1]

The nutrition transition [45,46] describes the process where a high prevalence of undernutrition is replaced by overnutrition through large changes in dietary intake and physical activity patterns, resulting in a diet primarily consisting of westernized, ultra-processed foods. [47,48] Though long believed to only affect individuals with high socioeconomic status, the obesity epidemic has increasingly spread to lower socioeconomic groups.[2] Several Latin American countries, including Argentina, Mexico,[49,50] and Brazil[51,52] have demonstrated this shifting burden across socioeconomic groups.[2]

Venezuela is a particularly salient case study as it is currently undergoing an economic and sociopolitical crisis that has led to widespread food shortages and malnutrition,[39] factors that may reverse the nutrition transition. Prior to the crisis, the burdens of T2D, hypertension, and obesity were documented to be increasing over time, particularly in urban areas.[34,53] However, few studies have looked at recent dietary intake in Venezuela[54,55] and most of these have been limited to convenience samples rather than nationally representative data.[56] Furthermore, NCD burden have been especially hard to quantify over the past few years, as the Venezuelan government has stopped publishing national statistics since 201.[42]

This paper aims to describe the relationship between dietary intake and obesity, hypertension, and T2D, using a nationally representative dataset from EVESCAM (Estudio Venezolano de

Salud Cardio-Metabólica). EVESCAM, conducted between 2014 and 2017, was the first nationally-representative study in Venezuela on risk factors for cardiometabolic disease, with data on NCDs including T2D, obesity, and hypertension; and lifestyle risk factors for these diseases.[43]

Methods

Study population

Data are from the EVESCAM study, a population-based, cluster-sampled study. Details of the study design and sampling strategy have been published elsewhere.[43] Briefly, between July 2014 and January 2017, 4,454 study participants were enrolled through a multi-stage stratified sampling method, using parish as the primary sampling unit. As such, these data are representative at the national level. Enrollment occurred at the household-level, where all members aged ≥20 years were invited to participate. Exclusion criteria included pregnancy, inability to stand or communicate, or refusal to participate.

Dietary intake assessment

Dietary intake was ascertained using a semi-quantitative food frequency questionnaire that was developed through a working group of Venezuelan nutrition experts and hosted by the EVESCAM principal investigators. The questionnaire (**Supplementary Table A2.1**) asked participants to list frequency of consumption and portion size for 33 food groups, based on show cards used to help estimate portion sizes accurately (**Supplementary Figure A2.1**). Responses were categorized by frequency: daily (1 portion, 2-4 portions, or ≥5 portions per day), weekly (1 portion, 2-4 portions, or ≥5 portions per week), or monthly (1 portion, 2-4 portions, or ≥5 portions per month). Responses were converted to frequency of daily intake using the median value of each category (e.g. 2-4 portions per week was recoded as 3 times per week or 0.43 times per day; 1-3 times per month was recoded as 2 times per month or 0.07 times per day). Water, sugar, and alcohol were excluded from this analysis.

A Dietary Diversity Score (DDS) was calculated to indicate the number of different food categories that participants reported consuming. This score was calculated based on Minimum Dietary Diversity-Women (MDD-W) developed by the Food and Agriculture Organization of the United Nations.[57] Based on the food groups collected in EVESCAM, the DDS used eight food categories rather than ten in MDD-W. This analysis categorized food groups as: 1) grains, white roots and tubes, plantains; 2) pulses; 3) Nuts and seeds; 4) Dairy; 5) Meat-based foods: red meat, poultry and fish; 6) Eggs; 7) Fruits 8) Vegetables. Food groups included in each category are listed in **Supplementary Table A2.2**. Each food category was given a score of zero if consumed weekly or less or one if at least one portion was consumed daily, and then a final score was created by summing all eight categories. Thus, a score of eight represents the most diverse diet and zero the least diverse diet.

Covariate assessment

Sociodemographic variables included sex, age, and socioeconomic status (SES). SES was calculated using a version of the Graffar Scale modified for Venezuela,[58,59] which pools income, profession, educational level, and housing conditions into a composite score. Each variable is rated independently from one to five, with one being the highest level of SES. A final score sums the independent ratings and classifies participants' SES as high, medium-high, medium, medium-low, and low.[60] Few participants were in the highest quintile (1.3%) that the two highest categories were merged.

Weight was measured with the lightest possible clothes, without shoes, using a calibrated scale (Tanita UM-081®, Japan). Height was measured using a portable stadiometer (Seca 206®

Seca GmbH & Co., Hamburg, Germany). Body mass index (BMI) was defined as weight (measured in kilograms) divided by height (measured in meters) squared, and classified as underweight (<18.5 kg/m^2), normal weight (18.5 to <25.0 kg/m^2), overweight (25.0 to <30.0 kg/m^2), or obesity (≥30.0 kg/m^2).[61]

Blood pressure was measured twice, in five-minute intervals, in the right arm using a validated oscillometric sphygmomanometer (Omron HEM-705C Pint® Omron Healthcare CO., Kyoto/Japan).[62] Participants were seated and rested their arm at heart level. Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.[63]

Blood glucose measurements included fasting blood glucose and a 2-hour oral glucose tolerance test (OGTT) using a 300-ml test solution containing 75 g anhydrous glucose. Diabetes was defined as either: fasting plasma glucose ≥126 mg/dL, 2-hour after 75g OGTT≥200 mg/dL, or self-report of diabetes medication use.[64] The mean age of diagnosis was 50.6 years and 7% of participants were on insulin only, so we refer to all participants as having T2D. Sensitivity analyses excluding one participant diagnosed at <21 years of age and on insulin only did not change results (data not shown).

Statistical analysis

Of 4,454 participants approached, 3,420 were enrolled in EVESCAM and included in the present analysis. As food group consumption was not always normally distributed, reporting only mean daily consumption would have been statistically inaccurate. For this reason, medians and interquartile ranges (IQR) were graphically represented using boxplots, one set of boxplots showing median consumption of Western foods and another for traditional foods. Western foods (eight total) included white bread, red meat, cookies, cake, soft drinks, fast food, french fries, and burgers.[46] Traditional foods (17 total) were determined based on previous studies categorizing Venezuelan dietary patterns,[65] and included arepas (a salted corn flour cake), coffee, cheese, white rice, vegetables, fruits, fruit juice, empanadas, oats, legumes, fish, poultry, eggs, plantains, potatoes, pasta, and soup. Cereal, cachapa, and nuts were not included in the boxplots as they were consumed monthly or less by over 75% of participants.

Bivariate analyses accounting for the complex survey design were conducted to estimate dietary intakes by sociodemographic characteristics, including age, sex, and SES, and clinical subgroups (i.e. body mass, hypertension, and T2D status) using Pearson chi-squared tests. Differences between mean DDS by subgroup were evaluated using Somers' D, a rank-sum test appropriate for weighted data.[66] This test also calculates jackknife standard error, adjusted for the primary sampling unit. Food groups were included in the bivariate analysis if they had a skewed distribution (**Figures 2.1 and 2.2**) to understand if their consumption might differ by subgroups and if they were consumed weekly or daily by >25% of participants.

All analyses were performed in Stata 16.0 (College Station, Texas, USA) using a complete case analysis. Data for all variables were missing for <5% of participants, apart from diet data for french fry and rice consumption which had 9% and 14% of data missing, respectively. The number and proportion of participants with missing covariate data are listed in **Supplementary Table A2.3.**

Results

Weighted characteristics of all participants, and by sex, are summarized in **Table 2.1**. Briefly, participants (n=3,420) were between 20-96 years of age, with a mean age of 41.2 years (SD 0.67) and 52.3% were female. The majority of participants lived in urban areas; only 19.3% of participants lived in rural areas. Most participants had BMI classified as overweight (34.5%;

95% Confidence Interval (CI): 31.8-37.4) or normal weight (36.6%; 32.5-40.7). Weighted prevalence of obesity was 24.6% (95% CI: 21.6-27.7), T2D 13.3% (11.2-15.7), and hypertension 30.8% (27.7-34.0). Underweight (4.3%; 95% CI: 3.2-5.8), extreme poverty (5.6%; 3.8-8.3), and high SES (2.0%; 0.9-4.4) were uncommon in the sample. Compared to females, there were significantly more male participants with T2D (15.9% of males vs 10.9% of females, p-value<0.001) and hypertension (32.8% of males vs 28.9% of females, p-value=0.055).

Table 2.1: Sociodemographic and clinical characteristics of adults*

	Weighted % (95%CI)			**P-value**[1]
	Total (n^2=3,402)	**Male** (n^2=1,052)	**Female**(n^2=2,348)	
Overall		47.7 (45.2-50.3)	52.3 (49.7-54.8)	
Socioeconomic Status[3]				0.320
High & Medium-High	21.2 (17.1-25.9)	22.3 (17.3-28.3)	20.1 (16.4-24.5)	
Medium	31.0 (27.8-34.3)	30.7 (26.6-35.2)	31.2 (28.1-34.5)	
Relative Poverty	42.2 (37.4-47.1)	40.7 (35-46.7)	43.6 (38.8-48.5)	
Extreme poverty	5.6 (3.8-8.4)	5.1 (3.4-7.5)	5.1 (3.4-7.5)	
Age Category				0.034
20-34	40.3 (36.0-44.6)	38.7 (32.9-44.9)	41.7 (37.3-46.3)	
35-44	21.5 (19.1-24.1)	20.9 (17.3-25.1)	22.1 (20.1-24.2)	
45-54	17.0 (15.6-18.6)	17.4 (15.1-19.9)	16.7 (15.1-18.5)	
55-64	11.4 (10.1-12.8)	11.1 (9.6-12.9)	11.6 (10.1-13.4)	
≥65	9.8 (8.0-11.8)	11.8 (9.7-14.4)	7.9 (6.3-9.8)	
Locality				0.047
Rural	19.3 (9.1-36.4)	17.7 (8.4-33.6)	20.8 (9.7-39.0)	
Urban	80.7 (63.6-90.9)	82.3 (66.4-91.6)	79.2 (61.0-90.3)	
BMI Category[4]				0.008
Underweight	4.3 (3.2-5.8)	3.5 (2.3-5.3)	5.1 (3.6-7.2)	
Normal Weight	36.6 (32.5-40.7)	36.2 (30.3-42.4)	36.9 (33.7-40.2)	

Table 2.1: (Continued)

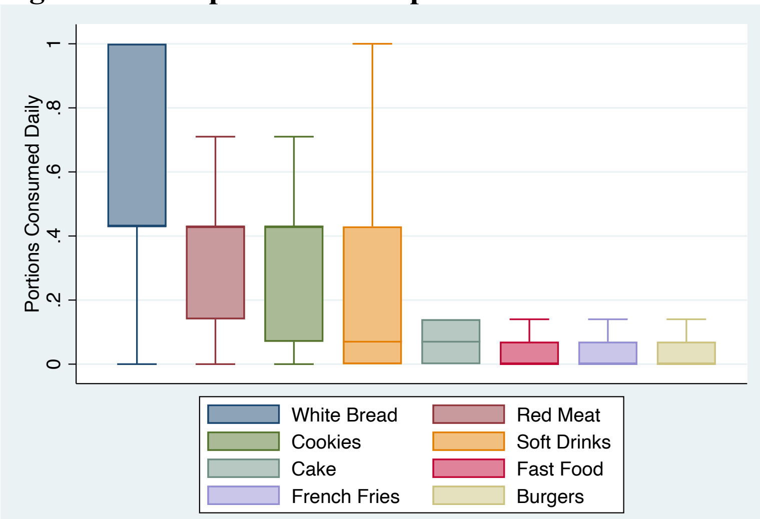
Overweight	34.5 (31.8-37.4)	38.2 (34.3-42.2)	31.2 (28.5-34.2)	
Obesity	24.6 (21.7-27.7)	22.2 (18.2-26.8)	26.7 (24.2-29.4)	
Type 2 Diabetes[5]	13.3 (11.2-15.7)	15.9 (13.2-19.0)	10.9 (8.9-13.3)	<0.001
Hypertension[6]	30.8 (27.7-34.0)	32.8 (29.2-37.2)	28.9 (25.7-32.2)	0.055

Note:
*Estimates are weighted to be representative of Venezuelan adults over 20 years of age
[1] P-values calculated using Pearson's chi-square.
[2] n=unweighted sample size
[3] SES was calculated using a version of the Graffar Scale modified for Venezuela,[58,59] which combines income, profession, educational level, and housing conditions into a composite score.
[4]BMI was defined as weight (measured in kilograms) divided by height (measured in meters) squared, and classified as underweight (<18.5 kg/m^2), normal weight (18.5 to <25.0 kg/m^2), overweight (25.0 to <30.0 kg/m^2), or obesity (≥30.0 kg/m^2)
[5]Type 2 diabetes was defined by either: fasting plasma glucose was ≥ 126 mg/dL, 2-hour after 75g oral glucose tolerance test ≥ 200 mg/dL, or self-report of diabetes medications.[64]
[6]Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.[63]

Consumption of Western & Traditional Foods

White bread had the most frequent and variable consumption of the Western food groups (**Figure 2.1**), with a median consumption of approximately three portions weekly (Median: 0.43, IQR: 0.43-1 portions daily). Red meat and cookies also had median consumption of three portions weekly but lower IQRs than white bread (red meat: 0.14-0.43 portions daily; cookies: 0.07-0.43 portions daily). Soft drinks had variable consumption patterns, despite low median consumption of 0.07 portions daily or approximately two portions monthly. Consumption of cake, french fries, burgers, and fast food was infrequent, with over 75% participants reporting consuming these food groups monthly or less.

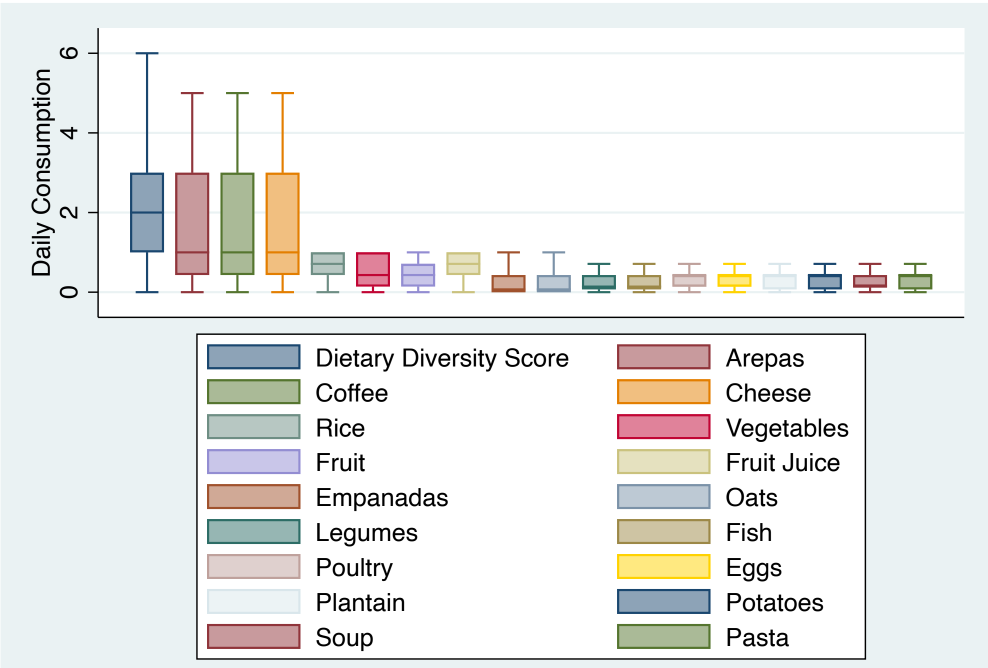
Figure 2.1. Boxplot of consumption of Western foods among Venezuelan adults, 2014-2017



Note: The values displayed here are median and interquartile range. This figure excludes outliers. Food groups are displayed as portions consumed daily.

Across all participants, median DDS was 2.00 (IQR: 1-3). The most commonly consumed traditional foods were arepas, coffee, and cheese, each with a median consumption of one time daily (IQR: 0.43-3 portions daily) (**Figure 2.2**).

Figure 2.2. Boxplots of consumption of traditional food groups and distribution of Dietary Diversity Score among Venezuelan adults, 2014-2017



Note: The values displayed here are medians and interquartile ranges. This figure excludes outliers. Dietary diversity score was calculated as an amended minimum dietary diversity-women (MDD-W) score, where each food category was given a score of 0 if consumed weekly or less or 1 if at least one portion was consumed daily, and then a final score was created by summing all eight categories. Food groups included in each category are listed in Appendix 3. Individual food groups are displayed as portions consumed daily.

Distribution of consumption by sociodemographic subgroups

Weighted bivariate analyses were conducted for DDS, white bread, red meat, cookies, soft drinks, arepas, coffee, cheese, vegetables, and fruits (**Tables 2.2 and 2.3**). As shown in **Table 2.2**, mean DDS was 2.28 (SE: 0.07) and did not vary by any sociodemographic subgroups.

Daily consumption patterns for a number of food groups differed by sex, namely white bread, cookies, soft drinks, cheese, and vegetables. Compared to females, a higher proportion of males reporting daily consumption of white bread (35% of males vs 29% of females; p=0.005) and soft drinks (17% vs 12% p=0.002). However, females consumed more cookies (18% of males vs 20% of females; p=0.0154), cheese (54% vs 60%; p=0.0115), and vegetables (29% vs 32%; p=0.0379) daily. There was no difference by sex for consumption patterns of fruit (p=0.102) or arepas (p=0.117).

Consumption patterns of white bread (p=0.126), cookies (p=0.963), soft drinks (p=0.081), and fruits (0.134) did not vary by SES. Participants with higher SES consumed more red meat weekly compared to those with lower SES (p<0.001): weekly consumption was 80% among those in the high & medium-high and medium categories, 69% among those in relative poverty, and 60% among those in extreme poverty. A similar pattern was observed for daily consumption of cheese (p=0.003) and vegetables (p<0.0001) where daily consumption was highest among those with high & medium-high SES (61% for cheese and 36% for vegetables in the highest SES category) compared to consumption among those in lower SES categories (45% for cheese and 23% for vegetables in the lowest SES category). However, consumption patterns were less linear for daily consumption of coffee and arepas. Daily arepa consumption was highest among participants in relative poverty (68%) and medium SES (66%), followed by participants in extreme poverty (63%), compared to participants in the high & medium-high category (54%) ($p=0.005$). Generally, lower SES category correlated with higher daily intake of coffee ($p=0.036$): daily coffee consumption was 73% among those in relative poverty and 70% among those in extreme poverty, compared to 66% among those in the medium SES category and 62% in the high and medium-high category.

Consumption patterns of white bread ($p=0.293$), cheese ($p=0.251$), and fruits ($p=0.322$) did not vary by age category. However, certain food groups were consumed more frequently by younger age groups compared to others. For instance, younger participants consumed more red meat weekly compared to older participants ($p<0.001$): weekly consumption was 78% among those <35-years-old and 75% among 45-54-year-olds, compared to 61% among >65-year-olds. Similarly, younger participants consumed more soft drinks weekly than older participants ($p<0.001$): weekly consumption was 41% among those <35-years-old, compared to 23% among 55-64-year-olds and 20% among >65-year-olds. Weekly vegetable consumption, however, was higher among older age categories ($p=0.014$) with 61% of those >65 years, 56% of those 55-65 years, and 59% of those 45-54 years consuming vegetables weekly, compared to 58% of those 35-44 and 56% <35 years of age.

The majority of food group consumption did not vary significantly by locality, with the exception of red meat ($p=0.003$). Red meat was most likely to be consumed weekly among those living in urban areas (76%) compared to those in rural areas (67%). Fruit consumption bordered statistical significance ($p=0.058$) and at least one portion of fruit was more likely to be consumed weekly in rural areas (67%) compared to urban areas (59%).

Distribution of consumption by cardiometabolic risk status

DDS did not differ by cardiometabolic risk status. Frequency of food group intake did differ by BMI category for red meat (p=0.033), arepas (p=0.013), and vegetables (p=0.011). Daily consumption of red meat and arepas was generally lower with increasing BMI category. For red meat, 10% of participants with an underweight BMI reported daily consumption and 7% of participants with normal weight, compared to 6% of participants with an overweight BMI. Participants with obesity, however, had slightly higher red meat consumption with 8% of participants reporting daily consumption. Daily arepa consumption was lower with increasing BMI category, with 74% of participants with an underweight BMI consuming arepas daily, compared to 66% with a normal BMI, 65% with an overweight BMI, and 59% with obesity. One-third of participants with obesity had daily vegetable intake compared to 30% with an overweight BMI and 22% of participants with an underweight BMI. There was no difference in vegetable intake by hypertension (p=0.57) or T2D status (p=0.68).

Consumption of red meat, soft drinks, arepas, and coffee differed significantly by T2D status. Those with T2D were less likely to consume red meat, soft drinks, and arepas daily: 4% of participants with T2D consumed red meat weekly compared to 7% without T2D (p=0.006), 13% of those with T2D consumed soft drinks daily compared to 15% without (p<0.001), and 60% of those with T2S consumed arepas daily compared 65% of those without. Daily coffee consumption, however, was more frequent among participants with T2D (78%) compared to those without T2D (67%).

Similarly, consumption of red meat, soft drinks, and arepas differed significantly by hypertension status. While daily consumption of red meat was 7% for both those participants with hypertension and those without, weekly consumption was 76% among those without hypertension compared to 70% among those with hypertension (p=0.002). Daily consumption of soft drinks ($p<0.001$) and arepas (0.043) were both higher among participants without hypertension: 16% of those without hypertension consumed soft drinks daily compared to 11% of those with hypertension, and 66% of those without hypertension consumed arepas daily compared to 61% of those with hypertension.

Table 2.2: Percent of Venezuelan adults consuming food groups by sociodemographic subgroups*

		Sex			SES[1]					Age						Locality		
	Total	Male	Female	P-value[2]	High & Medium - High	Medium	Relative Poverty	Extreme Poverty	P-value[2]	20-34	35-44	45-54	55-64	≥65	P-value[2]	Rural	Urban	P-value[2]
n[3]	3,402	1,057	2,345		656	1017	1,441	241		682	577	700	744	699		554	2848	
DDS[4]				0.131					0.734						0.703			0.405
Mean (SE)	2.28 (0.07)	2.21 (0.08)	2.34 (0.07)		2.27 (0.09)	2.30 (0.79)	2.29 (0.07)	2.37 (0.14)		2.28 (0.10)	2.33 (0.08)	2.23 (0.09)	2.31 (0.06)	2.19 (0.09)		2.11 (0.20)	2.32 (0.06)	
White Bread				0.005					0.126						0.293			0.274
Monthly	10%	7%	12%		7%	9%	11%	12%		9%	10%	8%	11%	12%		10%	9%	
Weekly	58%	58%	59%		56%	60%	59%	54%		61%	60%	58%	54%	52%		64%	57%	
Daily	32%	35%	29%		37%	31%	30%	34%		30%	31%	33%	36%	37%		26%	33%	
Red Meat				0.025					<0.001						<0.001			0.003
Monthly	19%	16%	21%		14%	13%	23%	36%		13%	17%	19%	27%	35%		28%	16%	
Weekly	74%	77%	72%		80%	80%	69%	60%		78%	76%	75%	70%	61%		67%	76%	
Daily	7%	7%	7%		6%	7%	8%	4%		9%	7%	6%	3%	4%		5%	8%	
Cookies				0.0154					0.963						0.016			0.298
Monthly	28%	31%	25%		28%	28%	28%	28%		26%	26%	30%	30%	34%		25%	29%	
Weekly	53%	51%	55%		52%	54%	53%	51%		52%	57%	54%	51%	51%		60%	51%	
Daily	19%	18%	20%		20%	18%	19%	21%		22%	17%	16%	19%	15%		14%	20%	
Soft drinks				0.002					0.081						<0.001			0.460
Monthly	50%	46%	54%		47%	51%	50%	61%		37%	48%	57%	68%	73%		53%	49%	
Weekly	36%	37%	34%		41%	34%	36%	22%		41%	40%	34%	23%	20%		37%	35%	
Daily	14%	17%	12%		12%	15%	14%	17%		21%	12%	9%	9%	7%		10%	15%	
Arepas				0.117					0.005						0.076			0.561
Monthly	3%	2%	4%		4%	2%	3%	5%		3%	3%	2%	3%	4%		4%	3%	
Weekly	33%	31%	34%		42%	32%	28%	32%		29%	33%	39%	34%	33%		29%	34%	
Daily	64%	67%	62%		54%	66%	68%	63%		68%	64%	58%	62%	63%		67%	64%	

Table 2.2: (Continued)

Coffee				0.012					0.036						<0.001			0.943
Monthly	19%	17%	20%		21%	21%	17%	21%		26%	17%	11%	11%	16%		19%	19%	
Weekly	13%	15%	11%		17%	13%	10%	9%		17%	12%	9%	9%	7%		13%	12%	
Daily	69%	68%	69%		62%	66%	73%	70%		57%	71%	79%	80%	69%		68%	69%	
Cheese				0.0115					0.003						0.251			0.592
Monthly	5%	5%	5%		3%	5%	6%	12%		4%	5%	7%	6%	66%		6%	5%	
Weekly	37%	40%	35%		36%	35%	39%	43%		36%	38%	39%	36%	41%		40%	37%	
Daily	57%	54%	60%		61%	60%	55%	45%		60%	58%	54%	58%	52%		54%	58%	
Vegetables				0.0379					<0.001						0.014			0.226
Monthly	12%	14%	11%		7%	8%	17%	17%		16%	8%	11%	11%	8%		15%	11%	
Weekly	57%	58%	57%		57%	59%	56%	59%		56%	58%	59%	56%	61%		62%	56%	
Daily	31%	29%	32%		36%	33%	27%	23%		28%	33%	30%	33%	31%		22%	32%	
Fruits				0.102					0.134						0.322			0.058
Monthly	18%	19%	17%		16%	16%	20%	25%		18%	18%	18%	18%	18%		15%	19%	
Weekly	61%	62%	60%		60%	61%	61%	56%		63%	61%	60%	59%	55%		67%	59%	
Daily	19%	19%	23%		24%	23%	19%	18%		19%	21%	21%	23%	28%		18%	22%	
Monthly	19%	17%	20%		21%	21%	17%	21%		26%	17%	11%	11%	16%		19%	19%	
Weekly	13%	15%	11%		17%	13%	10%	9%		17%	12%	9%	9%	7%		13%	12%	
Daily	69%	68%	69%		62%	66%	73%	70%		57%	71%	79%	80%	69%		68%	69%	

Note: *All estimates are weighted for complex survey design.
[1] SES was calculated using a version of the Graffar Scale modified for Venezuela,[58,59] which combines income, profession, educational level, and housing conditions into a composite score**.**
[2] For individual food groups, p-values were calculated using Pearson's chi-square, weighted for complex survey design. For DDS, p-values were calculated using Somers' D, weighted for complex survey design.
[3] n=unweighted sample size
[4]DDS was calculated as an amended minimum dietary diversity-women (MDD-W) score, where each food category was given a score of 0 if consumed weekly or less or 1 if at least one portion was consumed daily. A final score was created by summing all eight categories. Food groups included in each category are listed in Appendix 3. Jackknife SE is reported adjusted for the primary sampling unit, parish.

Food groups included in each category are listed in Appendix 2. Each food category was given a score of 0 if one to three portions were consumed weekly or less or 1 if one portion was consumed daily, and then a final score was created by summing all eight categories.
Acronyms: SES: Socioeconomic status, DDS: Dietary Diversity Score, SE: Standard error

Table 2.3: Percent of Venezuelan adults consuming food groups by cardiometabolic risk status*

		BMI Category[1]					Type 2 Diabetes[2]			Hypertension[3]		
	Total	**Under-weight**	**Normal weight**	**Overweight**	**Obesity**	**P-value[4]**	**No**	**Yes**	**P-value[4]**	**No**	**Yes**	**P-value[4]**
n[5]	3,402	133	1,198	1,204	853		2,790	601		1,908	1,493	
DDS[5]						0.315			0.630			0.879
Mean (SE)	2.28 (0.07)	2.62 (0.17)	2.31 (0.08)	2.18 (0.08)	2.29 (0.08)		2.29 (0.06)	2.21 (0.14)		2.27 (0.07)	2.29 (0.08)	
White Bread						0.405			0.456			0.605
Monthly	10%	8%	10%	10%	9%		10%	10%		10%	10%	
Weekly	58%	57%	58%	61%	57%		59%	56%		59%	57%	
Daily	32%	36%	33%	29%	35%		32%	35%		31%	34%	
Red Meat						0.033			0.006			0.002
Monthly	19%	32%	18%	19%	17%		18%	24%		17%	22%	
Weekly	74%	58%	76%	75%	75%		75%	72%		76%	70%	
Daily	7%	10%	7%	6%	8%		7%	4%		7%	7%	
Cookies						0.481			0.848			0.214
Monthly	28%	18%	28%	28%	30%		28%	29%		27%	30%	
Weekly	53%	57%	54%	54%	50%		53%	52%		53%	53%	
Daily	19%	25%	19%	18%	20%		19%	18%		20%	17%	
Soft drinks						0.2916			<0.001			<0.001
Monthly	50%	51%	53%	50%	46%		48%	64%		46%	59%	
Weekly	36%	29%	35%	37%	35%		38%	24%		38%	29%	
Daily	14%	19%	13%	14%	14%		15%	13%		16%	11%	
Arepas						0.013			0.025			0.043
Monthly	3%	1%	4%	2%	3%		3%	2%		3%	3%	
Weekly	33%	25%	30%	33%	38%		32%	39%		31%	36%	
Daily	64%	74%	66%	65%	59%		65%	60%		66%	61%	
Coffee						0.789			0.009			0.075

Table 2.3: (Continued)

Monthly	19%	18%	20%	17%	19%		20%	14%		20%	17%	
Weekly	13%	15%	13%	12%	12%		13%	8%		14%	10%	
Daily	69%	67%	67%	70%	69%		67%	78%		67%	73%	
Cheese						0.451			0.0929			0.875
Monthly	5%	5%	6%	5%	4%		5%	4%		14%	11%	
Weekly	37%	37%	40%	37%	35%		37%	42%		58%	57%	
Daily	57%	58%	55%	58%	61%		58%	54%		29%	32%	
Vegetables						0.011			0.478			0.5011
Monthly	12%	19%	14%	12%	7%		12%	11%		13%	11%	
Weekly	58%	59%	55%	58%	60%		58%	56%		57%	58%	
Daily	30%	22%	31%	30%	33%		30%	33%		30%	31%	
Fruits						0.099			0.8128			0.4633
Monthly	18%	15%	19%	17%	19%		18%	17%		17%	20%	
Weekly	61%	54%	58%	64%	61%		60%	62%		61%	59%	
Daily	21%	31%	24%	18%	20%		21%	21%		22%	21%	

Note:

[*]All estimates are weighted for complex survey design.

[1] BMI category was defined as weight (measured in kilograms) divided by height (measured in meters) squared, and classified as underweight (<18.5 kg/m^2), normal weight (18.5 to <25.0 kg/m^2), overweight (25.0 to <30.0 kg/m^2), or obesity (≥30.0 kg/m^2)

[2]Type 2 diabetes was defined by either: fasting plasma glucose was ≥ 126 mg/dL, 2-hour after 75g oral glucose tolerance test ≥ 200 mg/dL, or self-report of diabetes.[64]

[3]Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.[63]

[4]For individual food groups, p-values were calculated using Pearson's chi-square, weighted for complex survey design. For DDS, p-values were calculated using Somers' D, weighted for complex survey design.

[5] n=unweighted sample size

[6]DDS was calculated as an amended minimum dietary diversity-women (MDD-W) score, where each food category was given a score of 0 if consumed weekly or less or 1 if at least one portion was consumed daily. A final score was created by summing all eight categories. Food groups included in each category are listed in Appendix 3. Jackknife SE is reported adjusted for the primary sampling unit, parish.

Acronyms: BMI: body mass index, DDS: Dietary Diversity Score, SE: Standard error

Discussion

This nationally representative descriptive analysis of dietary patterns of Venezuelans in 2014-2017 found that the study population had a high prevalence of obesity, T2D, and hypertension. Most frequently consumed food groups included white bread, arepas, coffee, and cheese. Intake of many Western foods were relatively low, with over 75% of participants consuming french fries, burgers, and fast foods only monthly or less frequently.

In general, this analysis found females had healthier diets than males, with lower consumption of white bread, red meat, and soft drinks, although dietary diversity was similar between the sexes. There were inconsistent differences in intake by SES category: those with higher SES, compared to those in relative or extreme poverty, consumed more portions of some healthy foods (e.g. higher daily intake of fruit and vegetables), but also unhealthy foods (e.g. higher daily intake of white bread and cheese). Overall, younger and urban Venezuelans ate more Western foods than both older and rural Venezuelans.

Overall, dietary diversity was very low. Gomez et al. (2019), a study of eight Latin American countries, found that other countries have much more diverse diets with DDS scores of five to six (out of nine).[54] They found a slightly higher mean score in Venezuela than this analysis (5.62 of 9 compared to 2.3 of 8), but their study was conducted in only urban areas and during an earlier time period (2014-2015) than EVESCAM (2014-2017) which may have been affected by the onset of the humanitarian crisis in Venezuela.

Healthier food groups did not differ substantially by BMI category or T2D or hypertension status, but unhealthier foods (namely red meat, cheese, and arepas) were consumed more frequently by participants classified with overweight BMI and obesity, but less frequently by individuals with T2D and hypertension. This may suggest that people with diagnosed T2D and hypertension may follow positive behaviour change and nutritional recommendations made upon diagnosis.[67] Furthermore, individuals with obesity consumed more vegetables daily and consumed fewer soft drinks and cookies, potentially reflecting attempts to lose weight.

Although consumption of Western foods was low, the most commonly consumed food groups are not considered 'healthy' by most dietary guidelines for the region and worldwide.[68] White bread, arepas, and cheese dominated daily consumption in this nationally representative sample. In general, the composition of the cheeses in Venezuela have high fat content [37] and may be a factor contributing to obesity and T2D. In fact, a recent study in the US found that increasing cheese consumption by >0.5 servings per day was associated with 9% (95% CI: 2-16) higher risk of T2D, compared to maintaining usual cheese consumption.[69]

These results suggest that the nutrition transition has not influenced the dietary intake of Venezuela as markedly as other Latin American countries, such as Brazil and Mexico.[47,49,70,71] This could be due to the economic crisis in Venezuela, which started in 2014 and led to government restrictions on foreign products.[72] Meanwhile, traditional foods have long been subsidized by the government, possibly increasing their availability and consumption. Arepas, in particular, are considered a staple food in Venezuela. They are prepared from a cornmeal that is fortified with vitamin A and iron. The glycemic index is relatively high (74, which is similar to white wheat bread),[37] however, to our knowledge, no studies that have specifically evaluated the prospective association between arepas and obesity or T2D. However, given strong evidence linking refined grains to these outcomes,[73] one might posit that arepas may also increase risk and substituting for whole grains may increase risk. Unfortunately, it is unlikely that such substitutions would be culturally acceptable.

Despite markedly low consumption of Western, ultra-processed foods, the prevalence of obesity (24.6%) was higher in this sample than the regional average: in 2014, 19% of adults in Latin America were classified with obesity.[74] However, adult obesity prevalence remains lower in Venezuela than in Mexico or Chile, both with an obesity prevalence of approximately 35% in 2014.[75] Furthermore, obesity prevalence found in this sample is lower than previous estimates from before the socio-political crisis – one systematic review estimated that the prevalence of obesity in Venezuela was about 30% in 2009.[53] In a previous regional analysis that included the EVESCAM cohort but did not include any dietary data, obesity prevalence in Venezuela did not vary by urban versus rural areas and was generally highest in middle quartiles of educational attainment and lowest in the bottom quartile.[2]

In the present study, obesity prevalence was higher among women than men (26.7% versus 22.2%), a trend that matches obesity patterns worldwide and in other parts of Latin America.[2,47] Although some aspects of the diet in this Venezuelan cohort were healthier among women, the higher prevalence of obesity could be explained by several factors including body size preferences for women in Latino cultures,[76] lower physical activity levels (particularly work-related physical activity),[77] parity and resultant excess gestational weight gain/post-partum weight retention, and potentially genetic and/or hormonal differences.[2]

While prevalence for hypertension in our study was comparable to previous studies, the estimates for diabetes were higher. Here, the weighted prevalence was 13.1% (95% CI: 11.2-15.7), for T2D and 30.8% (27.7-34.0) for hypertension. Other studies reported diabetes prevalence to be about 8% and hypertension to be about 30%.[53,78,79] Differences in definitions of T2D and sampling may explain some of the discrepancies, however this warrants further study using longitudinal data.

This study has several strengths. First, EVESCAM is the first nationally representative study of Venezuelan diet and provides a better understanding of the nuances in dietary patterns throughout Latin America, particularly in a country undergoing a socio-political crisis and that has been neglected in global nutrition literature. This analysis provides nationally-representative estimates of diabetes, obesity, and hypertension prevalence during a time period where health data has been sparse in Venezuela. Further, a number of diverse traditional food groups specific to the study context, such as arepas, empanadas, and fried bananas, were included in the questionnaire, as well as pictures of portion sizes to ensure that participants could more accurately self-report the frequency of portions consumed.

Nonetheless, study design limitations must be taken into consideration. First, we cannot definitively rule out type 1 diabetes cases but globally over 95% of diabetes cases are T2D.[80] In this sample, however, very few participants were on insulin (7%) and average age of diagnosis was 50.6 years, so this was unlikely to be a major source of error in this analysis. Second, hypertension and diabetes definitions were based on a single measure, which introduces the risk of overestimating true prevalence in undiagnosed participants due to aberrant fasting or laboratory issues. However, given the context that data collection occurred, multiple data points were not feasible. Third, this cross-sectional study relied on self-reporting of semi-quantitative nutritional data collected at only one time point, which is prone to recall bias, impedes the ability to make causal inferences from this analysis, and may not reflect long-term consumption. The semi-quantitative nature of the questionnaire also limited our ability to calculate caloric intake from each food group. In general, countries around the world are increasingly shifting towards food-based dietary guidelines.[81] It was outside the aims and scope of this study to explore nutrient data such as energy and so the instrument used was not suitable to capture nutrient data.

Fourth, the nutrition questionnaire used organized answer options in a manner that may have increased measurement error. Specifically, frequency of consumption was in increasing order within daily, weekly, and monthly categories. However, this questionnaire was completed with the guidance of trained enumerators who supervised that answer choices matched the participants' consumption patterns using showcards with portion sizes. Finally, given the cross-sectional study design, the relationship between dietary intake and cardiometabolic indicators are subject to reverse causality, especially among participants aware of their diabetes and hypertension status. As such, our speculation that lower red meat, soft drink and arepa consumption among those with diabetes and hypertension reflects this possibility of reverse causality.

Further studies that employ validated quantitative methods to measure diet may assist in assessing diet more accurately, as well as conducting nutrient analysis. Moreover, future studies could also include recipes and preparation styles to better disaggregate ingredients included in mixed dishes. Lastly, since this study is conducted in a vulnerable population undergoing a humanitarian crisis, longitudinal data is needed to understand how food patterns have changed since baseline data collection in 2014-2017, when the crisis was already ongoing but less extensive. Diets might have changed among individuals with new cases of T2D or hypertension or with exacerbated complications of these conditions. Furthermore, though obesity was clearly a national problem in Venezuela at the time of data collection, this may have changed with food insecurity.

In summary, this nationally representative, cross-sectional analysis suggests that dietary intake among Venezuelans adults who remained in their homes in 2014-2017 are quite different from other countries in Latin America which have a high reliance on soft drinks and ultra-processed foods. Nutrition policy measures throughout Latin America should be tailored to consumption patterns and socio-political contexts of each country.

Chapter 3: Prevalence of Multimorbidity: Nationally Representative Comparisons of US Hispanics, Mexicans, and Venezuelans

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Abstract

Introduction: The burden of multimorbidity, defined as the coexistence of two or more diseases in the same individual, has increased worldwide alongside the epidemiologic transition. This analysis used nationally representative survey data from the 2014-2017 Venezuelan Study for Cardiometabolic Health (EVESCAM), the 2016 Mexican National Health and Nutrition Survey (ENSANUT), and Hispanic population of the 2015-2016 and 2017-2018 U.S. National Health and Nutrition Examination Surveys (NHANES) to compare multimorbidity prevalence in each population.

Methods: Analyses were repeated using two different multimorbidity outcomes based on data availability. Multimorbidity was defined as (1) ≥2 cardiometabolic diseases (obesity, T2D, hypertension, ACVE, high low-density lipoprotein cholesterol levels) for all three countries and (2), ≥2 cardiometabolic diseases or depression plus ≥1 cardiometabolic disease among Venezuelans and U.S. Hispanics.

All analyses used sampling weights to account for complex survey design. Bar charts were used to visualize multimorbidity prevalence by sex, age category, education level, and country; as well as the most common two- or three-disease combinations. Logistic regression was conducted for each multimorbidity outcome to explore predictors of multimorbidity.

Results: This analysis compared 3,418 adults in Venezuela to 2,167 adults in Mexico, and 1,350 Hispanic adults the US. Cardiometabolic multimorbidity prevalence was highest among U.S. Hispanics (29.3%; 95% CI: 26.1, 32.8), followed by Venezuelans (23.0%; 20.1, 26.3), and Mexicans (19.3%; 16.5, 22.4). When multimorbidity included depression, Venezuelans had a prevalence of 24% (95% CI: 21.0, 27.3) compared to 38.3% (35.1, 41.6). among US Hispanics.

For all three countries, the most common comorbidity combination was hypertension and obesity (9.2% among Mexicans, 14.1% among US Hispanics). When multimorbidity included depression and cardiometabolic conditions, 12.3% of US Hispanics had co-occurring obesity and depression. Adjustment for sex, age, education, daily fruit and vegetable intake, alcohol use, smoking, and physical activity attenuated the association between country and cardiometabolic disease multimorbidity but not cardiometabolic disease and depression multimorbidity.

Discussion: Our findings point to a high prevalence of multimorbidity in Venezuela, the US, and Mexico (ranging from 19.3-29.3%) and that cardiometabolic morbidities are particularly likely to co-occur. Even during a humanitarian crisis, we found prevalence of multimorbidity among Venezuelans to be lower than that of Latinos in the US.

Introduction

The prevalence of multimorbidity, defined as the coexistence of two or more diseases in the same individual, has increased worldwide alongside the epidemiological transition.[5] Compared with individuals with only one illness in isolation, those with multimorbidity experience higher disability and mortality.[6] For example, a pooled analysis from the Emerging Risk Factors Collaboration (1970-2013) of 698,300 individuals from 18 high income countries found mortality rates per 1000 person-years were 15.6 in participants with a history of diabetes, 16.1 in those with stroke, 16.8 in those with myocardial infarction (MI), compared to 32.0 in those with both diabetes and MI, 32.5 in those with both diabetes and stroke, 32.8 in those with both stroke and MI, and 59.5 in those with diabetes, stroke, and MI.[82] Multimorbidity has also been linked to frequent health care utilization. A population-based study in Denmark found that, rates of healthcare utilization were 1.4-4.0 times higher for people with multimorbidity, when compared to those with one chronic condition.[83] As such, multimorbidity is costly to both patients and the health system.[7]

While noncommunicable disease (NCD) research has pivoted towards investigating multimorbidity rather than individual diseases,[13] there remains no consensus on which diseases to include in studies of multimorbidity.[9] Moreover, despite ample evidence for higher multimorbidity prevalence at an earlier onset among individuals with lower socioeconomic status,[10] there are far fewer studies in LMICs and among disadvantaged populations.[11-13]

Generally, Latin American populations are vulnerable to multimorbidity[12] as the region is experiencing an increase in both longevity and NCD prevalence.[6] Few studies have compared multimorbidity between Latin American populations in different countries,[11] despite the Americas being a diverse region with varying demographic, political, and nutritional contexts.[6,84]

For instance, Venezuela has been experiencing a catastrophic humanitarian crisis since 2014, which has caused a major disruption in the healthcare system and widespread food insecurity.[85] Simultaneously, Mexico is an upper-middle income country with a universal healthcare system[86] and, throughout the last century, has undergone the nutrition transition; that is, a widespread switch from traditional, plant-based diets to consumption of industrialized foods with added sugars, high in saturated fats, and from animal sources.[87] Across the border, Hispanic populations in the U.S. have also been documented to have generally poor diet quality,[88] but live in a high-income country with stark social and health inequalities among minority groups. Even after the establishment of the Affordable Care Act, Hispanics are nearly three times more likely to be uninsured than non-Hispanic whites[89] and health disparities are further heightened among undocumented Hispanics.[90] In all three countries, despite high NCD rates and low access to care,[91] patterns of multimorbidity, including combinations of co-occurring diseases, remain largely understudied.[11-13]

The objectives of this study were to use nationally representative survey data from Venezuela, Mexico, and Hispanics in the U.S. to compare multimorbidity patterns and sociodemographic correlates of odds of multimorbidity in these three distinct settings.

Methods

Data Sources

<u>Venezuela: 2014-2017 Venezuelan Study of Cardiometabolic Health</u>

Estudio Venezolano de Salud Cardio-Metabólica (EVESCAM) is a population-based study where participants were enrolled using multi-stage stratified random sampling between July 2014 and January 2017. Details of the study design and sampling strategy have been published elsewhere.[92] Enrollment occurred at the household-level, where all members aged ≥20 years were invited to participate. Exclusion criteria included pregnancy, inability to stand or communicate, or refusal to participate. The present analysis included 3,418 individuals ≥20 years of age.

Mexico: 2016 National Health and Nutrition Survey

The Encuesta Nacional de Salud y Nutrición (ENSANUT) is population-based survey regularly conducted by the Mexican National Institute of Public Health. Details of the sampling strategy and study design have been previously published.[93] Briefly, ENSANUT provides a nationally representative sample of the civilian non-institutionalized population and uses multi-stage probability design that includes oversampling households with lower socioeconomic status. Households were excluded if they were an uninhabited private household or absent during the time of the interview. The present analysis included 2,167 non-pregnant individuals ≥20 years of age who participated in the 2016 survey, all of which had available laboratory data for cholesterol and fasting blood glucose.

US Hispanics: 2015-2016 and 2017-2018 National Health and Nutrition Examination Survey

The US National Health and Nutrition Examination Survey (NHANES) is a repeated cross-sectional survey conducted throughout all 50 states and the District of Columbia and provides a nationally representative sample of the noninstitutionalized civilian population.[94] NHANES uses a multi-year, stratified, clustered four-stage sampling method, with data released in 2-year cycles. This includes oversampling Hispanic Americans, non-Hispanic black Americans, non-Hispanic Asian Americans, and individuals aged 0-11 and over 80 years. Exclusion criteria includes those who refused to participate, military personnel and citizens living abroad. This analysis used data from 1,350 Hispanic participants aged 20+ who participated in either the 2015-2016 or 2017-2018 NHANES cycle, had laboratory data available, and were not pregnant at the time of data collection.

Morbidities

Obesity was defined as BMI ≥30.0 kg/m^2, based on measured weight and height.[61] Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mm Hg, or self-reported current use of antihypertensive medication.[63] Information on acute cardiovascular events (ACVE) was available as self-reported history of MI or stroke.

Diabetes and elevated low-density lipoprotein cholesterol (LDL) were determined using blood samples using standardized laboratory procedures for each survey.[43,93] T2D was defined as fasting plasma glucose ≥126 mg/dl, non-fasting plasma glucose ≥200 mg/dL, or self-reported current use of diabetes medication.[64] High LDL was defined as LDL ≥130 mg/dL or self-reported current use of medication for dyslipidemia.[95]

Depression was measured using the Patient Health Questionnaire (PHQ-9) for US Hispanics in NHANES and Hospital Anxiety and Depression Scholar (HADS) survey for Venezuelans in EVESCAM. Previous studies validating these two questionnaires found few differences between them when used to diagnose depression, without considering severity.[96,97] Depression data were not available in the 2016 ENSANUT.

<u>Covariate definition</u>

As socioeconomic status is reported/measured markedly differently in each survey and likely not comparable, education was used as a surrogate. Education was classified into three categories: low (did not complete high school or completed 'secundaria' or below), middle (completed high school), and high (above high school).

For ENSANUT, dietary intake was ascertained using a Food Frequency Questionnaire (FFQ) that asked participants to list frequency of consumption and portion size over the past week.[98] Dietary intake in EVESCAM was ascertained using a semi-quantitative FFQ that asked participants to list frequency of consumption over the past month and portion size for 33 food groups, based on show cards used to help estimate portion sizes accurately.[99] NHANES used two 24-hour recalls to collect dietary data where participants were asked to list all foods and beverages they consumed the previous day. This analysis only considered data from the first recall. Ingredients were disaggregated from mixed dishes for all three countries. Total fruit and vegetable consumption was categorized based on USDA recommendations (none, less than 5 servings daily, 5+ servings daily).[100]

Alcohol consumption from Mexico and Venezuela was collected using the FFQs where Mexico asked about consumption over the last 7 days and Venezuela asked about the last month. The U.S. had a separate questionnaire specifically for alcohol use over the last 12 months. All three surveys specified all types of alcoholic beverages including beer, wine, and spirits. We categorized participants as non-drinkers, less than daily drinkers, and daily drinkers.

Cigarette smoking was based on self-reported answers. In all three countries, participants were asked if they had smoked at least 100 cigarettes in their lives and if they now smoke. In Venezuela, participants were asked about smoking 20 cigars or 20 pipes in their lifetime in the same question. We categorized smoking into never smoking, former smokers, and current smokers.

Physical activity was measured using the International Physical Activity Questionnaire (IPAQ) for Mexico and Venezuela and the Global Physical Activity Questionnaire (GPAQ) for the US, both designed and validated to assess physical activity in different cultural settings.[101]A nine-country reliability and validity study found that GPAQ has moderate-strong positive correlation with IPAQ.[102] Both questionnaires calculate metabolic equivalent (MET) scores for work-related physical activity, active transportation, and leisure-time physical activity. We categorized physical activity levels as low (<600 METS), moderate (600-3000 METS), and high (≥3000 METS).[103]

Statistical analyses

All analyses used sampling weights that accounted for the survey design and the subpopulation included in this analysis. We created a subpopulation of participants ≥20 years of age in ENSANUT and a subpopulation of Hispanic participants ≥20 years of age in NHANES. For both studies, we used survey weights specific to individuals included in the random laboratory sample.[94] For Venezuela, all participants enrolled were ≥20 years of age and participated in laboratory measurements. To compare the three countries, sample weights were rescaled by the survey's sample size, so all countries contributed equally to summary estimates. Sensitivity analyses were conducted without rescaling and findings were not affected.

We calculated the prevalence of each morbidity and covariate (sex, age, education, daily fruit and vegetable intake, alcohol use, smoking, and physical activity) for each country and compared estimates using chi-squared tests with Rao–Scott correction F-statistic to account for survey design.

Subsequent analyses were conducted for two multimorbidity outcomes, depending on data availability for a given country. For this reason, the analyses were repeated twice using alternative multimorbidity definitions. In the first analysis, that included data from all three countries, multimorbidity was defined as at least two cardiometabolic diseases (obesity, T2D, hypertension, ACVE, high low-density lipoproteins). The second analysis based only among Venezuelans and U.S. Hispanics, defined multimorbidity as at least two cardiometabolic diseases or depression plus one or more cardiometabolic disease.

For each multimorbidity combination, bar graphs were used to visualize prevalence and 95% confidence intervals (CI) by sex, age category, education level and applicable country. We also estimated the prevalence and 95% CI for every two- and three-morbidity combination.

Finally, to compare predictors of multimorbidity between these three countries, we used three weighted logistic regression models for each multimorbidity combination. The first model adjusted for country; the second model adjusted for country, sex, and age; and the third adjusted for country, age, sex, and all sociobehavioral predictors (education, daily fruit and vegetable intake, alcohol use, smoking, and physical activity). Sensitivity analyses included investigating an interaction between country and sociobehavioral risk factors. The only evidence of an interaction was between country and smoking status for multimorbidity among Venezuelans and US Hispanics (defined as ≥2 cardiometabolic diseases or depression). We conducted a complete-case analysis as less than 5% of participants were missing data for any covariates. The number and proportion of participants with missing covariate data are listed **Appendix Table S3.1**. All analyses were performed in Stata 17.0 (College Station, Texas, USA).

Results

<u>Sample Characteristics</u>

This analysis compared 3,418 adults in Venezuela to 2,167 adults in Mexico, and 1,350 Hispanic adults the US. Nationally representative demographic and sociobehavioral characteristics are listed in **Table 3.1**. Approximately half of the sample were male [47.8% (45.3, 50.4) of Venezuelans, 44.0% (95% CI: 40.3, 50.4) of Mexicans, and 50.0% (47.5, 52.5) of U.S. Hispanics] and approximately 20% of the sample were above 55 years of age [21.2% (18.7, 23.9), 18.9% (16.3, 21.8), and 24.4% (20.0, 29.4), among Venezuelans, Mexicans, and U.S. Hispanics, respectively]. Participants in Mexico had the lowest educational attainment as 68.0%

(95% CI: 64.1, 71.6) did not complete high school compared to 18.5% (15.3, 22.1) in Venezuela and 34.6% (30.2, 39.3) of U.S. Hispanics. Venezuela had the lowest fruit and vegetable intake with 60.2% (95% CI: 55.6, 64.6) consuming no daily servings, compared to 23.9% (20.6, 27.7) in Mexico and 14.2% (11.4, 17.5) among U.S. Hispanics. Venezuela also had the smallest percentage of participants who were current cigarette smokers (Venezuela: 12.2%; 95% CI: 10.5, 14.2. US Hispanics: 15.1%; 12.7, 17.8. Mexico: 21.1%; 17.7, 25.0.)

Table 3.1: Nationally Representative sociodemographic characteristics and behavioral risk factors for adults in Venezuela (2014-2017), Mexico (2016), and US Hispanics (2015-2016 and 2017-2018)

	Venezuela[1] (n=3,418)		Mexico[2] (n=2,167)		U.S. Hispanics[3] (n=1,350)	
	%	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**
Male	47.8	(45.3, 50.4)	44.0	(40.3, 47.8)	50.0	(47.5, 52.5)
Age category						
<35 years	40.3	(36.1, 44.7)	40.2	(36.3, 44.4)	33.3	(29.1, 37.8)
35-44 years	21.4	(19.0, 24.1)	21.2	(18.6, 24.1)	23.9	(21.0, 27.2)
45-54 years	17.1	(15.7, 18.6)	19.7	(17.1, 22.5)	18.3	(16.3, 20.6)
55+ years	21.1	(18.7, 23.9)	18.9	(16.3, 21.8)	24.4	(20.0, 29.4)
Education[4]						
Low	18.5	(15.3, 22.1)	68.0	(64.1, 71.6)	34.6	(30.2, 39.3)
Medium	42.3	(39.4, 45.3)	21.5	(18.5, 24.9)	24.8	(20.6, 29.6)
High	39.2	(35.0, 43.6)	10.5	(7.9, 13.8)	40.6	(35.6, 45.8)
Fruit and vegetable intake						
None	60.2	(55.6, 64.6)	23.9	(20.6, 27.7)	14.2	(11.4, 17.5)
Once daily	22.5	(19.9, 25.3)	25.2	(21.5, 29.2)	73.7	(69.5, 77.6)
2-4 daily	14.2	(12.2, 16.4)	25.3	(22.3, 28.5)	4.7	(3.3, 6.7)
5+ daily	3.2	(2.4, 4.2)	25.6	(22.7, 28.8)	7.4	(5.3, 10.2)
Cigarette smoking						
Never	68.6	(66.1, 71.0)	42.2	(37.9, 46.7)	63.2	(59.8, 66.6)
Past	19.2	(17.5, 21.0)	36.7	(32.5, 41.1)	21.7	(18.8, 24.8)
Current	12.2	(10.5, 14.2)	21.1	(17.7, 25.0)	15.1	(12.7, 17.8)
Alcohol Use						
Not currently drinking	54.6	(50.3, 58.9)	76.8	(73.0, 80.1)	27.2	(23.6, 31.0)
Less than daily drinker	43.3	(39.2, 47.5)	14.3	(11.9, 17.1)	71.1	(67.1, 74.7)
Daily drinker	2.1	(1.1, 4.0)	8.9	(6.7, 11.8)	1.8	(1.1, 2.9)
Physical Activity[5]						
Low	35.1	(30.8, 39.7)	13.5	(11.0, 16.3)	52.2	(47.3, 57.2)
Moderate	27.0	(24.5, 29.6)	9.0	(7.0, 11.6)	34.6	(30.3, 39.1)
High	37.8	(33.4, 42.5)	77.5	(74.0, 80.7)	13.2	(10.8, 15.9)

Notes:
*P<0.05 for all covariates when comparing estimates by country using chi-squared tests with Rao–Scott correction F-statistic to account for survey design.
[1]Data for Venezuela from Estudio Venezolano de Salud Cardio-Metabólica (EVESCAM 2014-2017)

[2]Data for Mexico from Encuesta Nacional de Salud y Nutrición (ENSANUT 2016)
[3]Data for US from the National Health and Nutrition Examination Survey (NHANES 2015-2016 and 2017-2018)
[4]Education was categorized as low if the participant did not complete high school, middle if completed high school, and high if above high school.
[5]Physical activity levels categorized as low (<600 METS), moderate (600-3000 METS), and high (≥3000 METS).[103]

Weighted cardiometabolic multimorbidity prevalence was lower among Venezuelans (23%; 95% CI: 20.1, 26.3) than among US Hispanics (29.3%; 26.1, 32.8), but higher than among Mexicans (19.3%; 16.5, 22.4) (**Table 3.2**). When multimorbidity included depression, Venezuelans had a prevalence of 24% (95% CI: 21.0, 27.3) compared to 38.3% (35.1, 41.6). among US Hispanics.

Table 3.2: Nationally representative disease prevalence in Mexico (2016), Venezuela (2014-2017), and US Hispanics (2015-2016 and 2017-2018)

	Venezuela[1] (n=3,418)		**Mexico[2] (n=2,605)**		**U.S. Hispanics[3] (n=1,689)**	
	%	**(95% CI)**	**%**	**(95% CI)**	**%**	**(95% CI)**
Diabetes	13.4	(11.3, 15.8)	12.3	(10.3, 14.6)	16.5	(14.3, 19.0)
Obesity	24.5	(21.6, 27.6)	36.6	(33.0, 40.3)	45.5	(41.6, 49.6)
Hypertension	30.8	(27.7, 34.0)	18.2	(15.7, 21.0)	27.4	(23.9, 31.2)
High LDL	11.3	(9.1, 13.9)	12.9	(10.4, 15.8)	19.6	(16.6, 23.0)
ACVE	3.0	(2.6, 3.5)	1.4	(0.9, 2.2)	4.1	(2.9, 5.7)
Depression	3.2	(2.5, 4.0)			25.5	(22.4, 28.7)
Cardiometabolic Multimorbidity[4]	23.0	(20.1, 26.3)	19.3	(16.5, 22.4)	29.3	(26.1, 32.8)
Cardiometabolic/Depression Multimorbidity[5]	24.0	(21.0, 27.3)			38.3	(35.1, 41.6)

Notes: Significant differences in prevalence between countries (P<0.02)
[1]Data for Venezuela from Estudio Venezolano de Salud Cardio-Metabólica (EVESCAM 2014-2017)
[2]Data for Mexico from Encuesta Nacional de Salud y Nutrición (ENSANUT 2016)
[3]Data for US from the National Health and Nutrition Examination Survey (NHANES 2015-2016 and 2017-2018)
[4]Cardiometabolic Multimorbidity is defined as two or more of the following conditions: diabetes, obesity, hypertension, high LDL, or ACVE.
[5]Cardiometabolic/Depression Multimorbidity is defined as two or more of the following conditions: diabetes, obesity, hypertension, high LDL, ACVE, or depression.

Multimorbidity prevalence by subgroup

In all three countries and for every outcome combination, multimorbidity prevalence was higher for women than men and higher with increasing age category (**Figures 3.1-3.2**).

Multimorbidity prevalence was generally lower by increasing educational attainment in Venezuela and Mexico, though such an inverse relationship was less clear among US Hispanics.

Figure 3.1: Prevalence of cardiometabolic multimorbidity by sex, age, and education for Mexico (2016), Venezuela (2014-2017), and US Hispanics (2015-2016 and 2017-2018)

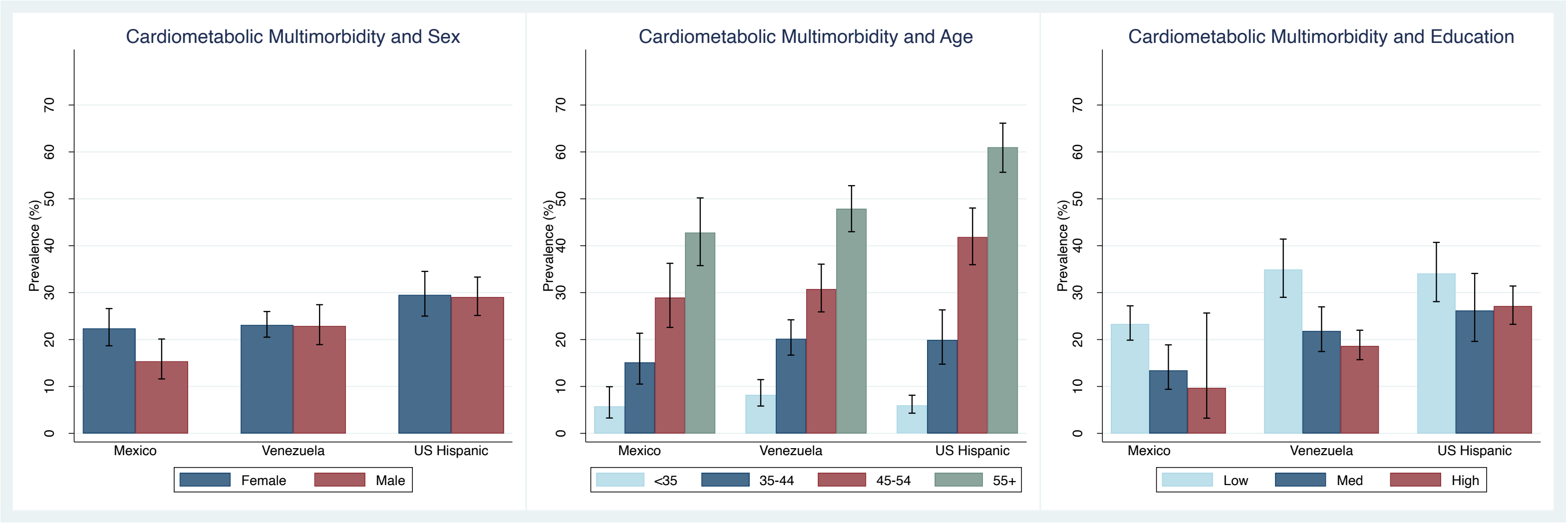
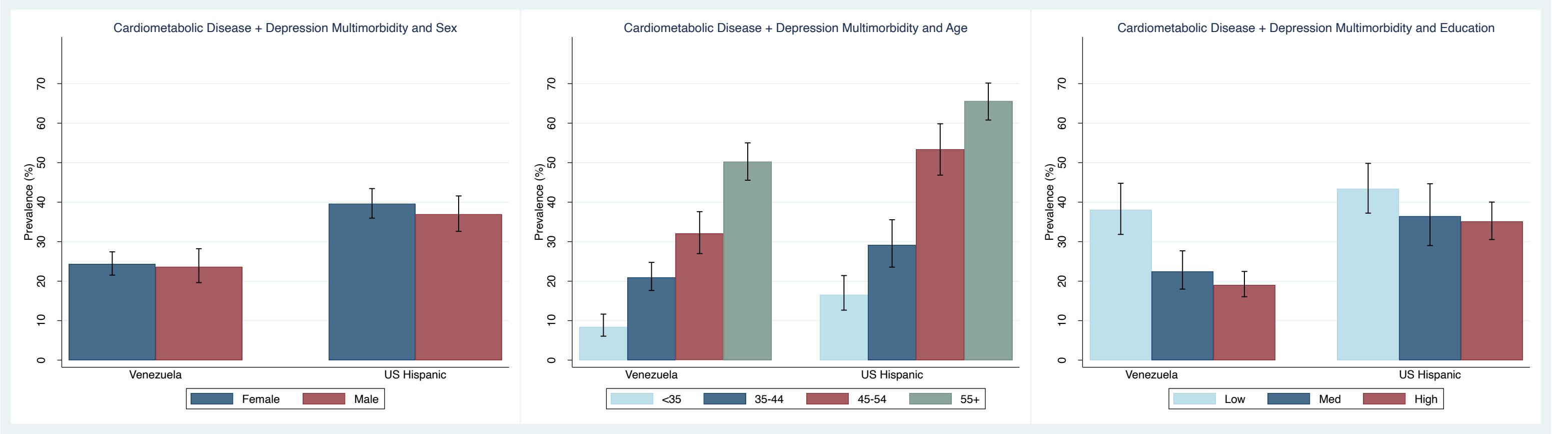


Figure 3.2. Prevalence of cardiometabolic disease + depression multimorbidity by sex, age, and education in Venezuela (2014-2017) and US Hispanics (2015-2016 and 2017-2018)



Multimorbidity patterns

Figures 3.3-3.4 show nationally representative prevalence of the most common combination of two- and three-morbidity combinations for each multimorbidity outcome. All combinations and 95% CIs are listened in **Appendix Tables S3.3-3.4**. For both multimorbidity outcomes and in all populations, the most common two-disease combination was hypertension and obesity, and the most common three-morbidity combination was hypertension, obesity, and T2D. For multimorbidity defined as two or more cardiometabolic diseases or depression, 12.3% (95% CI: 10.3, 14.7) U.S. Hispanics had co-occurring depression and obesity and 7.1% (5.5, 9.2) had depression and hypertension (**Figure 3.4: Panel B**). Conversely, for Venezuelans, depression co-occurred most frequently with hypertension, with a prevalence of 1.4% (95% CI: 1.0, 1.9)

Figure 3.3. Multimorbidity Patterns: Cardiometabolic Diseases among Venezuelans, Mexicans & US Hispanics

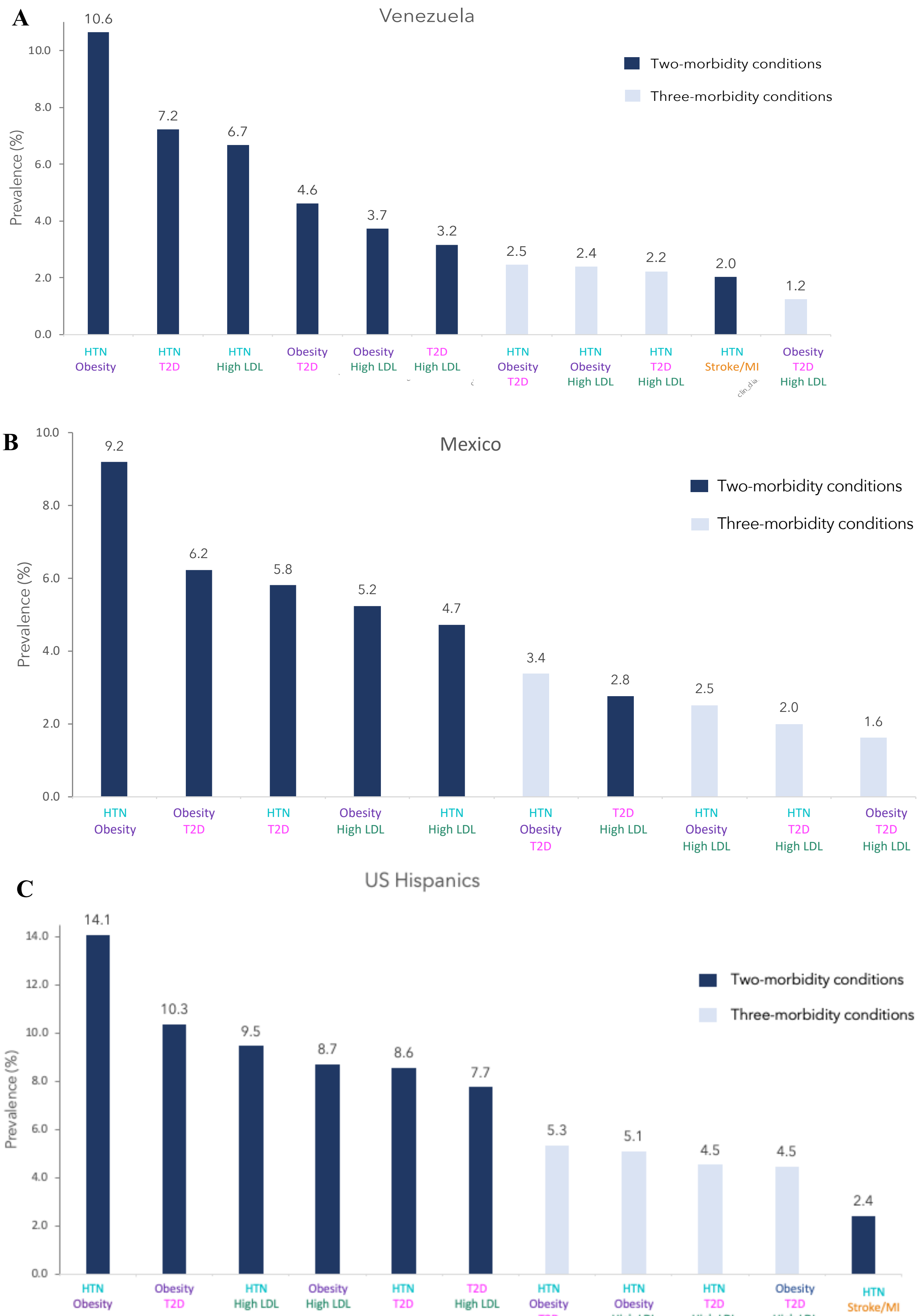
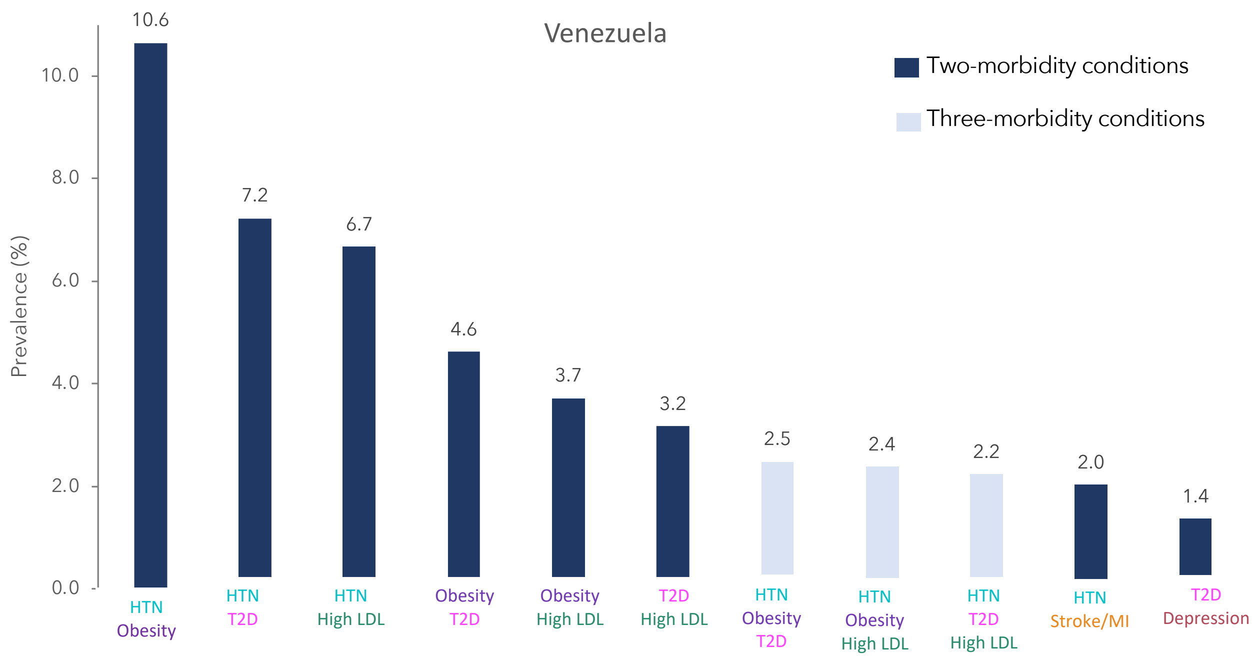
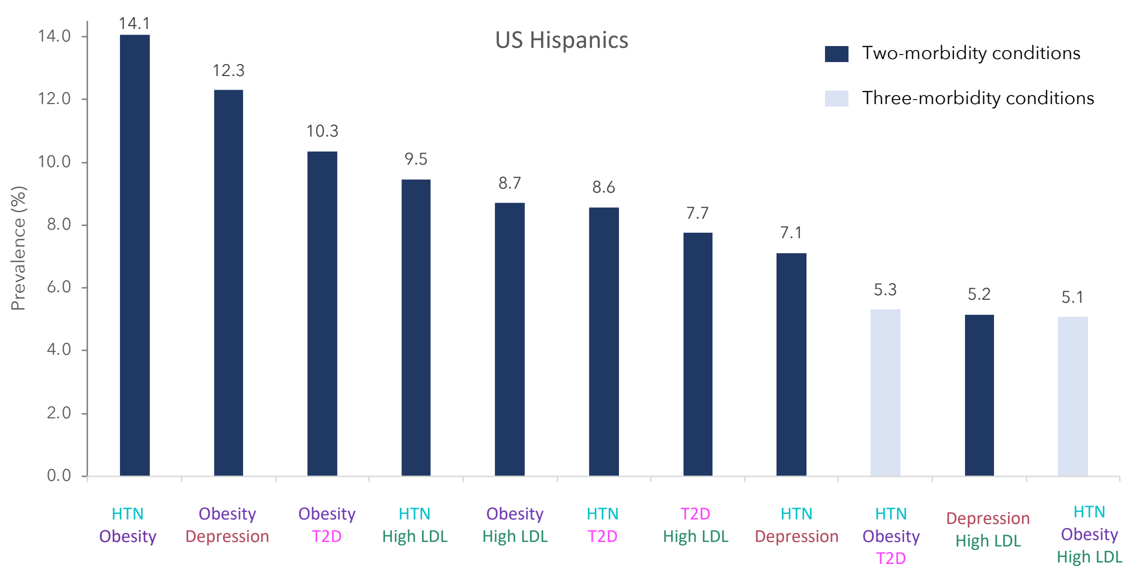


Figure 3.4. Multimorbidity Patterns: Cardiometabolic Diseases + Depression among Venezuelans & US Hispanics

A



B



Variation of multimorbidity prevalence by country, demographic, and sociobehavioral characteristics

Table 3.3 shows the association with country of residence with odds of cardiometabolic multimorbidity. After adjustment for sex and age, individuals living in Venezuela had 28% (OR: 1.28; 95% CI: 0.99, 1.67) and Hispanics in the US had 66% (1.66; 1.28, 2.16) increased odds of having two or more co-occurring cardiometabolic diseases, compared to individuals in Mexico. Further adjustment for sociobehavioral factors attenuated the association between country and cardiometabolic disease multimorbidity.

Table 3.3: Univariate and multivariate logistic regression analyses assessing multimorbidity of cardiometabolic diseases, among Mexicans (2016), Venezuelans (2014-2017), and U.S. Hispanics (2015-2016 and 2017-2018)

	Model 1	**Model 2**	**Model 3**
	OR(95% CI)	**OR(95% CI)**	**OR(95% CI)**
Country			
Mexico	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
Venezuela	1.25 (0.97, 1.61)	**1.28 (0.99, 1.67)**	1.18 (0.87, 1.61)
US Hispanic	**1.73 (1.36, 2.21)**	**1.66 (1.28, 2.16)**	1.37 (0.95, 1.98)
Male		**0.84 (0.71, 0.99)**	0.83 (0.68, 1.01)
Age category			
<35		1.0 (Ref)	1.0 (Ref)
35-44		**3.10 (2.31, 4.15)**	**3.11 (2.26, 4.28)**
45-54		**7.17 (5.27, 9.74)**	**6.92 (4.92, 9.72)**
55+		**14.53 (11.05, 19.10)**	**13.27 (9.69, 18.17)**
Education			
Low			1.0 (Ref)
Medium			0.87 (0.69, 1.10)
High			0.79 (0.62, 1.01)
Fruit and vegetable intake			
None			1.0 (Ref)
Once daily			1.1 (0.90, 1.35)
2-4 daily			0.91 (0.71, 1.17)
5+ daily			0.88 (0.58, 1.33)
Smoking			
Never			1.0 (Ref)
Past			1.19 (0.96, 1.46)
Current			1.01 (0.73, 1.39)
Alcohol Use			
Not currently drinking			1.0 (Ref)
Less than daily drinker			0.96 (0.81, 1.15)

Table 3.3: (Continued)

Daily drinker	0.90 (0.43, 1.88)
Physical Activity	
Low	1.0 (Ref)
Moderate	0.91 (0.72, 1.15)
High	**0.70 (0.55, 0.89)**

Notes: Estimates are bolded if p-value<0.05

When multimorbidity was defined as two or more cardiometabolic diseases or depression and after controlling for all covariates, US Hispanics had 51% (OR: 1.51; 95% CI: 1.12, 2.03) higher odds of multimorbidity compared to Venezuelans (**Table 3.4**). Compared to non-smokers, both past smokers and current smokers had increased odds of multimorbidity (past: OR: 1.26; 95% CI: 0.97, 1.64. current: 1.61; 1.16, 2.22). Stratified models by country indicated that physical activity was protective for Venezuelans but not for US Hispanics (**Appendix Tables S3.6-7**). Specifically, individuals in Venezuela with moderate and high physical activity levels had, respectively, 21% (OR: 0.79; 95% CI: 0.64, 0.98) and 37% (OR: 0.63, 0.45, 0.87) lower odds of cardiometabolic disease or depression multimorbidity, compared to their counterparts with low physical activity. Among Hispanic individuals in the US, however, there was no evidence of an association between physical activity and cardiometabolic disease or depression multimorbidity (moderate vs low physical activity: OR 0.93; 95% CI: 0.64, 1.33. high vs low physical activity: OR 1.19; 95% CI: 0.80, 1.78).

Table 3.4: Univariate and multivariate logistic regression analyses assessing multimorbidity of cardiometabolic diseases + depression multimorbidity, Venezuela (2014-2017) and US Hispanics (2015-2016 and 2017-2018)

	Model 1	**Model 2**	**Model 3**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Country			
Venezuela	1.0 (Ref)	1.0 (Ref)	1.0 (Ref)
US Hispanic	**1.96 (1.58, 2.44)**	**1.97 (1.60, 2.43)**	**1.51 (1.12, 2.03)**
Male		0.92 (0.79, 1.07)	**0.83 (0.69, 1.01)**
Age category			
<35		1.0 (Ref)	1.0 (Ref)
35-44		**2.37 (1.77, 3.17)**	**2.38 (1.75, 3.24)**

Table 3.4: (Continued)

45-54	**5.45**	**(4.16, 7.14)**	**5.34**	**(4.03, 7.08)**
55+	**10.18**	**(8.01, 12.95)**	**9.34**	**(6.89, 12.66)**
Education				
Low				1.0 (Ref)
Medium			0.89	(0.69, 1.15)
High			**0.76**	**(0.59, 0.98)**
Fruit and vegetable intake				
None				1.0 (Ref)
Once daily			**1.23**	**(0.99, 1.53)**
2-4 daily			1.08	(0.80, 1.44)
5+ daily			0.74	(0.42, 1.31)
Smoking				
Never				1.0 (Ref)
Past			1.26	(0.97, 1.64)
Current			**1.61**	**(1.16, 2.22)**
Alcohol Use				
Not currently drinking				1.0 (Ref)
Less than daily drinker			0.95	(0.78, 1.14)
Daily drinker			0.87	(0.41, 1.83)
Physical Activity				
Low				1.0 (Ref)
Moderate			**0.78**	**(0.63, 0.96)**
High			**0.62**	**(0.44, 0.85)**
Country*Physical Activity				
US*Low				1.0 (Ref)
US*Moderate			1.17	(0.79, 1.74)
US*High			**1.91**	**(1.16, 3.14)**

Notes: Estimates are bolded if p-value<0.05

Discussion

This pooled study of three nationally representative surveys found that cardiometabolic multimorbidity was most prevalent among US Hispanics, followed by Venezuelans and then Mexicans. Cardiometabolic diseases were most likely to co-occur for Venezuela and Mexico. Among US Hispanics, however, depression and obesity were the second highest co-occurring diseases. Even during a humanitarian crisis, prevalence of comorbidity in Venezuela is lower than that of Latinos in the US.

In all three countries, the present study found a strong positive association of multimorbidity with increasing age, lower education, and female sex that is consistent with two recent meta-analyses of multimorbidity in LMICs.[11,12] Furthermore, logistic regression models controlling for education, fruit and vegetable intake, smoking, alcohol use, and physical activity found no significant association between country of residence and odds of multimorbidity when defined as two or more cardiometabolic diseases in the US, Venezuela, and Mexico. For these diseases, differences in univariate multimorbidity prevalence were likely explained by sociobehavioral factors, rather than an unmeasured environmental or contextual differences between countries. Study participants in Mexico had lower multimorbidity prevalence, on average, but these differences were attenuated in our fully adjusted models, therefore the association between country of residence and odds of morbidity may have been explained by education, fruit and vegetable intake, smoking, alcohol use, and physical activity.

However, in Venezuela and the US, when multimorbidity was defined as two or more cardiometabolic diseases or depression, controlling for sociobehavioral factors did not attenuate the association between country of residence and odds of multimorbidity, suggesting that there was a contextual difference by country that was not explained by any variables included in the models, such as access to healthcare or exposure to racism and other stressors.

The unadjusted weighted depression prevalence was much lower in Venezuela (3.2%) than among US Hispanics (25.5%). On one hand, such low depression prevalence in Venezuela was surprising as the country has been undergoing a catastrophic humanitarian crisis, typically a setting known to exacerbate mental health conditions such as depression and anxiety.[104] A study of 394 Venezuelan migrants in Peru[105] found that 19% of their sample qualified for a depression diagnosis as defined by the Spanish version of the PHQ-9, the same questionnaire used in NHANES which is comparable to the questionnaire used in EVESCAM for non-severe diagnoses. Our study population in Venezuela, however, had not migrated by 2014-2017 and thus likely faces different stressors than migrants in neighboring countries. Furthermore, those with previous diagnoses of depression and who might rely on anti-depressant medication might have been more likely to emigrate earlier as access to continuous medication has been reportedly sparse throughout Venezuela.[106] Our estimates from this analysis match those from a previous analysis using EVESCAM baseline data, which found 3.2% of participants to have depression;[107] both estimates are only slightly lower than the World Health Organization's and Global Burden of Disease's estimates for Venezuela in 2015 (4.2%).[108] The impact of the crisis on the mental health of Venezuelans who did not emigrate remains unknown, but local researchers have suggested that cultural characteristics might influence these results and anxiety may perhaps be a larger burden than depression.[107]

Conversely, we found that about a quarter of US Hispanics in our study had depression and an eighth had comorbid obesity and depression. Although our data were cross-sectional, our findings support a recent prospective study that found Hispanic populations in the US may be more vulnerable to the obesogenic consequences of depression than non-Hispanic white and black populations.[109] The exact mechanisms remain unknown, though a study of health behaviors and obesity in the US found that Hispanics with depression were 14% more likely not to participate in leisure-time physical activity, compared to their non-Hispanic white counterparts.[110] Furthermore, a growing consensus among epidemiological evidence has documented the health impacts of racism in the United States, especially against Hispanic/Latino and African American populations, and these health impacts include mental health conditions and cardiometabolic conditions.[111-113]

For all three countries and all definitions of multimorbidity, hypertension and obesity were the most common comorbidities. Generally, diabetes, obesity, hypertension and high LDL were the most likely conditions to co-occur. A 2022 systematic review and meta-analysis of

NCD multimorbidity prevalence and patterns in LMICs supported our findings, concluding that cardiometabolic conditions were among the most identified patterns to occur as they share risk factors such as diet and smoking.[12]

There are several limitations to this study to consider. First, several variables were at risk of recall and measurement bias. Several measures, namely dietary data, depression, alcohol, smoking, ACVE were measured with questionnaires relying on self-report. For example, more sensitive questions regarding depression, alcohol and smoking are more likely to be underreported. Furthermore, the questionnaires for diet, depression, and alcohol varied between studies by collecting data from different time frames and asking questions slightly differently. However, we pooled the three datasets to only compare similar variables. For instance, alcohol intake was collected over the past 7 days in ENSANUT, 30 days in EVESCAM, and 12 months in NHANES; so, we only included questions about daily alcohol intake from each questionnaire to be as comparable as possible. Second, data on non-cardiometabolic diseases were not available for all three countries. However, we were able to create several multimorbidity outcomes relevant for the US and Mexico, the US and Venezuela, or just the US to gain insight on how depression might co-occur with cardiometabolic diseases. Third, our estimates for Mexico might be slightly under-reported as we analyzed the 2016 wave of ENSNAUT to match the NHANES and EVESCAM time frames. Specially, the 2018-2020 ENSANUT found a prevalence of 30% for hypertension[114] and 16% for diabetes,[115] while the present study found 18.2% and 12.3%, respectively. Unlike previous ENSANUT analyses, however, our hypertension and diabetes definitions did not include self-reports of previous diagnoses to match clinical guidelines.[63,64]

Despite the aforementioned limitations, this analysis has a number of strengths. First, we provide a nationally representative account of which morbidity combinations are most common in three unique populations in the Americas during the same 3-year period (2014-2017). Previous multimorbidity studies have rarely investigated which diseases co-occur, instead including count of diseases or as a binary outcome, that is, presence of two or more diseases or not.[11-13] Other multimorbidity studies in Venezuela and Mexico either restricted enrollment to populations over 60 years of age[116,117] or used disease definitions primarily based on self-report.[6,116,118] To our knowledge, no previous study has compared multimorbidity burden among US Hispanics to populations living in possible countries of origin. Furthermore, we included a range of conditions in our analysis: obesity, hypertension, diabetes, high LDL, hypertension, ACVE, and, depression. All conditions except acute cardiovascular events were based on laboratory measurements or validated questionnaires. Our study highlights the need to include objective, standardized protocols for nationally representative surveys to better compare the burden of multimorbidity between countries.

Future studies should focus on understanding policies and interventions that seek to prevent and manage multimorbidity in LMICs, particularly as multimorbidity burden progresses alongside global aging. These results support the importance of policies focused on mitigating shared environmental and behavioral risk factors. Furthermore, primary care should focus on integrated management of multimorbidity rather than single conditions.[119]

Chapter 4: The diabetes care continuum in Venezuela: cross-sectional and longitudinal analyses to evaluate engagement and retention in care

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Abstract
Background: The impact of the humanitarian crisis in Venezuela on care for noncommunicable diseases (NCDs) such as diabetes is unknown.

Methods: This longitudinal study on NCDs is nationally representative at baseline (2014-2017) and has follow-up (2018-2020) data on 35% of participants. Separate analyses of the baseline population with diabetes (n=585) and the longitudinal population with diabetes (n=210) were conducted. Baseline analyses constructed a weighted care continuum with six stages: all diabetes; diagnosed; treated; achieved glycaemic control; achieved blood pressure, cholesterol, and glycaemic control; and achieved aforementioned control plus non-smoking. Weighted multinomial regression models controlling for region were used to estimate the association between sociodemographic characteristics and care continuum stage. Longitudinal analyses constructed an unweighted care continuum with four stages: all diabetes; diagnosed; treated; and achieved glycaemic control. Unweighted multinomial regression models controlling for region were used to estimate the association between sociodemographic characteristics and changes in care continuum stage.

Findings: Among 585 participants with diabetes at baseline, 71% (95% CI: 64-77%) were diagnosed, 51% (45-56%) were on treatment, and 32% (28-36%) had achieved glycaemic control. Among 210 participants with diabetes in the longitudinal population, 50 (24%) participants' diabetes management worsened, while 40 (19%) participants improved. Specifically, the proportion of those treated decreased (60% [95% CI: 54-67%] in 2014-2017 to 51% [44-58%] in 2018-2020), while the proportions of participants achieving glycaemic control did not change.

Interpretation: Though treatment rates have declined substantially among participants in EVESCAM, management of diabetes did not change as much as expected during this humanitarian crisis.

Introduction

People affected by humanitarian crises, whether internally displaced or refugees, are especially vulnerable to exacerbated chronic health conditions due to disrupted health services, irregular medication access, and unpredictable food supplies.[18] Simultaneously, humanitarian crises are becoming increasingly longer in duration. In 2019, nearly 78% of refugees worldwide were in a protracted situation, defined as more than 25,000 refugees from the same country displaced for at least five years.[19] Such crises are also projected to become more common. The number of internally displaced people is projected to rise to 143 million by 2050 in Sub-Saharan African, South Asia, and Latin America due to climate-related disasters.[120] As such, humanitarian aid and global health actors have become increasingly concerned with the management of noncommunicable diseases (NCDs), such as diabetes, in these widespread and prolonged crises.[18,21,22]

NCD management requires continuous care and, thus, prolonged engagement with the health system.[21] Living with diabetes, for example, involves continuous medication, glucose monitoring, dietary intervention, patient education, and regular visits to health facilities.[18,24,25] Barriers to diabetes management include food insecurity, discontinuity of care, and economic hardship, and these barriers are especially exacerbated in crises. For example, diet quality and diversity have been documented to suffer in crises as carbohydrate rich foods become staples. Chapter Two of the present dissertation conducted a nationally representative assessment of dietary patterns among Venezuelans in 2014-2017 and found that dietary diversity was very low: on average, people consumed just 2 food groups daily with the primary food groups consumed including white bread and arepas (a salted corn cake).[99] Another challenge in diabetes care during crises is psychosocial trauma that can lead to neglecting health care until advanced disease and life-threatening complications present.[25] Diabetes management also requires adherence to medication and testing, which largely depends on supply and access to appropriate medications, glucose meters, and test strips.[25,26] These barriers introduce a number of challenges to diabetes management in crisis settings, though research in this area remains largely uncharted. Given the difficulties of conducting data collection in these contexts, only a few studies have quantitatively evaluated changes in disease management among people living with diabetes who remained in their home countries during crises.[26-32] Results of these studies have been mixed: three studies documented that average Haemoglobin A1c (HbA_{1c}) increased after exposure to crises;[26,28,32] two studies found HbA_{1c}increased only among those on public insurance[30] or with insulin-dependent diabetes;[27] one study found no changes in mean $HbA_{1c;}$[31] and another study found a decrease in mean HbA_{1c}.[29]

In this study, we examine changes in diabetes management during a humanitarian crisis. Venezuela is a unique case study for NCDs in crises as its socio-political, economic, and nutritional contexts have deteriorated rapidly only in the last decade. Prior to the crisis, Venezuela was a flourishing upper-middle income country[33] and the burden of diabetes, hypertension, and obesity were documented to be increasing over time, particularly in urban areas, mirroring the nutritional and epidemiological transitions in neighboring South American countries.[34-36] In the early 2000s, the Venezuelan government augmented primary and chronic care programs through a mission between the Cuban and Venezuelan governments. This campaign, known as *Misión Barrio Adentro,* built numerous primary care centers throughout the country, staffed these centers with Cuban doctors, and provided cost-free diabetes drugs, although this program only covered 24% of the population with diabetes.[35,37] The other public services, however, remained highly underfunded and lacking coordination as the majority of people with diabetes received care in public facilities.[35] Furthermore, as a result of the gross mismanagement of oil reserves and national funds,[38] hyperinflation and food shortages led to food insecurity and a malnutrition crisis.[39] Over 5 million Venezuelans have fled the country since 2014 and no estimates exist for the number of internally displaced individuals.[40,41] Shifts in the NCD burden have been challenging to quantify, as the Venezuelan government stopped publishing national statistics in 2016.[42] However, recent nationally-representative analyses led by academic researchers estimated diabetes prevalence to be between 12-13% in 2014-2017, with approximately 2.5 million adults living with diabetes in Venezuela during that period.[99,121]

The specific objectives of this study were to (1) document health system performance for diabetes management in a nationally representative sample of Venezuela in 2014-2017 using the continuum of care framework, (2) assess changes in health system performance over time, from 2014-2017 to 2018-2020, and (3) quantify the association between sociodemographic characteristics and care continuum stage. This is the first longitudinal continuum of care analysis for diabetes and results from this study will explain how diabetes management was affected during a humanitarian crisis.

Methods

<u>Study population</u>

Data are from the EVESCAM study (Estudio Venezolano de Salud Cardio-Metabólica),[43] a longitudinal evaluation of NCDs conducted in Venezuela between 2014 and 2020. EVESCAM has nationally representative data at baseline and follow-up data on a subset of 35% of participants. Details of the study design and sampling strategy have been published elsewhere.[43] Briefly, between July 2014 and January 2017, 3420 study participants were enrolled through a multi-stage stratified sampling method, using parish as the primary sampling unit. Enrolment occurred at the household level, where all members aged ≥20 years were invited to participate.

The response rate was 77.3%. Exclusion criteria included pregnancy and inability to stand or communicate.[43] The baseline period occurred over three years and enrolment occurred by region, resulting in a strong correlation between time and region. As such, the study was not designed to make any causal claims regarding the effect of the crisis, instead it aimed to provide nationally representative estimates for NCDs.

Between October 2018 and January 2020, study staff contacted and visited every participant enrolled at baseline. If the participant was reachable, study staff collected informed consent and, if provided, continued with clinical measurements and questionnaires as conducted at baseline, along with an updated protocol to measure humanitarian indicators, such as food insecurity, medication access, and stressful life events.

Diabetes definition

Blood glucose measurements included fasting plasma glucose (FPG) and a 2-hour oral glucose tolerance test (OGTT) using a 300-ml test solution containing 75 g anhydrous glucose. Diabetes was defined as either: FPG ≥126 mg/dL, 2-hour OGTT ≥200 mg/dL, or self-report of previous diagnosis of diabetes by a clinician.[64]

Diabetes continuum of care

This paper employs the continuum of care framework to identify where patients are lost in the Venezuelan health system. The continuum of care, or cascade of care, framework was initially developed to quantify the effectiveness of the health care system in diagnosing and treating HIV.[122] It has since been applied to health system performance for diabetes care.[123,124] The approach allows for easy identification of where in the continuum the greatest losses to care occur, facilitating the creation of targeted interventions to address these gaps.[125] Diabetes management has been evaluated using the continuum of care approach in high-income[124,126] and low-income and middle-income countries (LMICs),[123,127-131] but this framework has yet to be applied to a crisis setting. In this paper, we refer to the framework as the continuum of care to signify the dynamic, bidirectional navigation of the spectrum of diabetes care.[132]

Two care continua were constructed for this analysis: an ABC (HbA1c, blood pressure, and cholesterol) diabetes care continuum[124] and a simplified continuum. The six stages of the ABC diabetes care continuum were: all diabetes; diagnosed; treated; achieved glycaemic control; achieved blood pressure, cholesterol, and glycaemic control [herein referred to as ABC control]; and ABC control and non-smoker. The derivation of each stage is described in detail below. The four stages of the simplified diabetes care continuum were: all diabetes; diagnosed; treated; and achieved glycaemic control, also described in detail below.

All diabetes: All participants with an FPG ≥126 mg/dL or 2-hour OGTT ≥200 mg/dL.

Diagnosed: This subset of participants met the above criterion and self-reported having a previous diabetes diagnosis by a clinician.

Treatment: This subset of participants met the above criteria and self-reported currently taking diabetes medication.

Glycaemic Control: This subset of participants met the above criteria and achieved glycaemic control, defined as FPG ≤154 mg/dL, the equivalent of 7% HbA1C.[133]

ABC Control: This subset of participants met the above criteria and had blood pressure control (systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg)[63] and low-density lipoproteins (LDL) cholesterol levels below 100 mg/dL.[95]

ABC Control and Non-smoker: This subset of participants met the above criteria and self-reported never smoking in the past 12 months.

All continua were calculated with a fixed denominator of all participants with diabetes. The numerator was the subset of participants with diabetes who reached a given stage and to reach that stage participants had to achieve all previous stages.

Covariates

At each study visit, weight was measured with the lightest possible clothes and without shoes using a calibrated scale (Tanita UM-081®, Japan). Height was measured with a portable stadiometer (Seca 206® Seca GmbH & Co., Hamburg, Germany). Body mass index (BMI) was defined as weight (measured in kilograms) divided by height (measured in meters) squared, and categorized as overweight/obesity (≥25.0 kg/m^2) or underweight/normal weight (<25.0 kg/m^2).[134] Underweight and normal weight were combined as few participants in both baseline and follow-up population were underweight (BMI<18.5): 3.96% and 3.27%, respectively.

Blood pressure was measured twice with a five-minute break in between measurements in the right arm using a validated oscillometric sphygmomanometer (Omron HEM-705C Pint® Omron Healthcare CO., Kyoto/Japan).[62] Participants rested their arm at heart level while seated. Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.[63]

LDL levels were measured from fasting blood samples using standardised laboratory procedures.[43] High LDL was defined as ≥100 mg/ dL, the Adults Treatment Panel III (ATP III) guidelines of the National Cholesterol Education Program cut-off for optimal HDL level.[95]

Sociodemographic variables included sex, age, and socioeconomic status (SES). SES was calculated using a version of the Graffar Scale modified for Venezuela,[58,59] which pools income, profession, educational level, and housing conditions into a composite score. Each variable is rated independently from one to five, with one being the highest level of SES. A final score sums the independent ratings and classifies participants' SES as high, medium-high, medium,

medium-low (relative poverty), and low (extreme poverty).[60] Few participants included in the follow-up analysis were in the highest (1.3%) and lowest quintiles (7.8%), and so the two highest and two lowest categories were merged to create three categories: high and medium-high (herein 'high'), medium, and relative and extreme poverty (herein 'low'). Data on sex, age, and SES were missing for <5% of participants. The number and proportion of participants with missing data are listed in **Supplementary Table A4.1.**

<u>Statistical analysis</u>

All analyses were performed in Stata 17.0 (College Station, Texas, USA). Analyses involving the baseline population accounted for complex study design. Analyses that included follow-up measurements were not weighted as the follow-up sample was not representative.

Baseline Analyses

The nationally representative ABC continuum of care estimated proportions and 95% confidence intervals using complex survey weights with restricted estimation to 585 participants with diabetes at baseline.

Weighted multinomial logistic regression models were used to evaluate relative risk ratios (RRR) between sociodemographic and clinical characteristics and position on the simplified continuum of care to ensure sufficient sample size (>5) in each stage. Predictors included previously well-established risk factors for diabetes,[135] namely, sex (female versus male), age category (<50 years, 50-59 years, ≥60 years), SES (high, medium, and low), urban residence (versus rural), overweight/obesity (versus underweight/normal weight), having hypertension (versus not), or having high LDL (versus not). All models adjusted for participants' regional residence. The outcome variable was defined as one of three positions on the care continuum (diagnosed, treated, or controlled) compared to undiagnosed.

Longitudinal Analyses

The longitudinal, simplified continuum of care were limited to 210 participants with diabetes at baseline and follow-up data. Individuals with incident diabetes between baseline and follow-up measurements (n=43) were excluded to only analyze individuals already receiving care for diabetes at baseline. Paired t-tests were used to compute statistical differences between the proportions of participants in each stage of the continuum at follow-up compared to baseline.

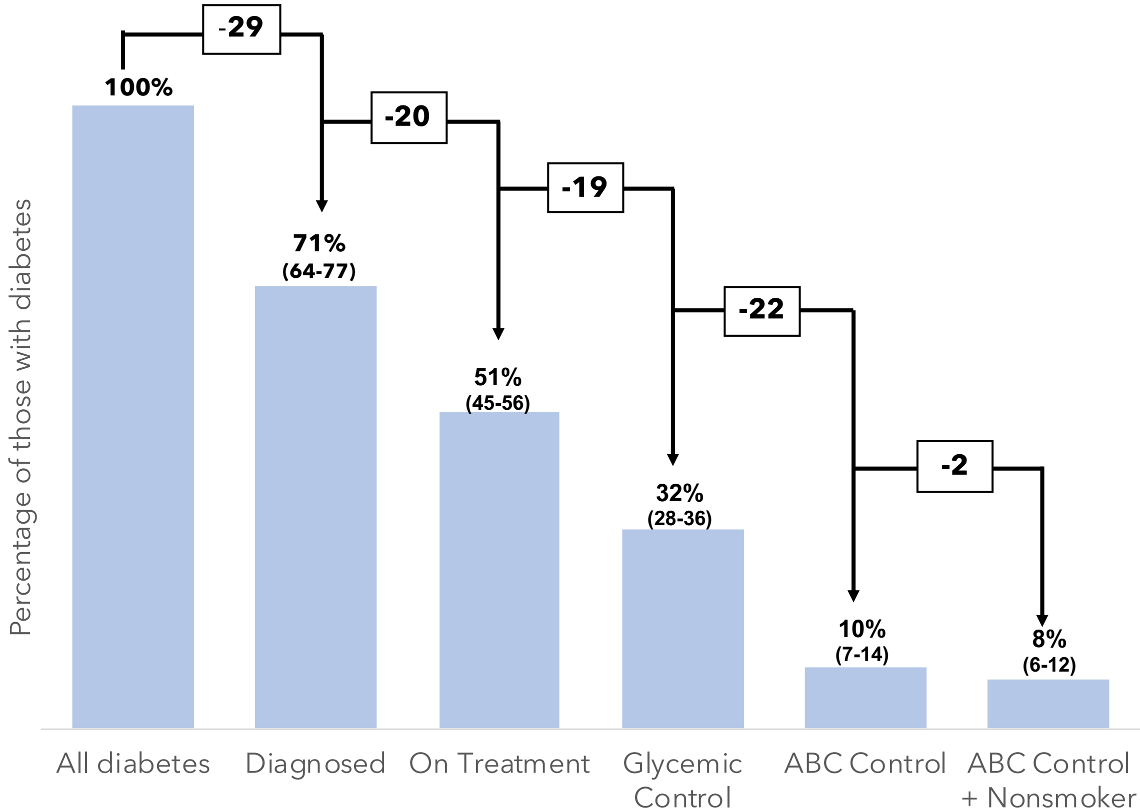
Multinomial logistic regression models were used to examine the relative risk ratios (RRR) between baseline characteristics and either increasing or decreasing in care continuum stage (vs staying the same). To determine this outcome, participants were given a score at both baseline and follow-up based on their position on the continuum (1 for all diabetes, 2 for diagnosed, 3 for on treatment, and 4 for controlled). The difference between the two scores was calculated and then separated into three categories: worsened, stayed the same, or improved.

Results

Baseline Analyses

Nationally representative sociodemographic characteristics are listed in **Supplementary Table A4.2**. Among 585 Venezuelan adults with diabetes in 2014-2017, 71% (95% CI: 64-77) were diagnosed, 51% (45-56) were on treatment, 32% (28-36) achieved glycaemic control, 10% (7-14) achieved ABC control, and 8% (6-12) achieved ABC control and were non-smokers (**Figure 4.1**). The greatest loss to care was at diagnosis (29% of participants lost and, thus, undiagnosed).

Figure 4.1: Nationally representative ABC continuum of care for diabetes among 585 Venezuelan adults, 2014-2017



Note: Estimated proportions and 95% confidence intervals calculated using complex survey weights. ABC Control refers to A1C, blood pressure, and cholesterol control.

Compared to younger participants, older participants were more likely to be on treatment [relative risk ratio (RRR) (95% CI), 2.61 (1.17, 5.81)] and achieve glycaemic control [RRR (95% CI), 2.28 (1.17, 5.81)] compared to being undiagnosed (**Table 4.1**). Otherwise, these data found no evidence between sociodemographic characteristics and position on the care continuum.

Table 4.1: Relative Risk Ratios of Position in Simplified Diabetes Continuum at Baseline among 585 Venezuelan adults in 2014-2017, Weighted Multinomial Analyses[1]

Covariate of interest	**Diagnosed vs Undiagnosed**		**On Treatment vs Undiagnosed**		**Controlled vs Undiagnosed**	
	RRR	(95% CI)	RRR	(95% CI)	RRR	(95% CI)
Female (vs Male)	1.67	(0.79 , 3.50)	1.40	(0.63 , 3.09)	1.83	(0.95 , 3.54)
Age						
<50 years	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
50-59 years	0.90	(0.36,2.27)	**2.61**	**(1.17,5.81)**	**2.28**	**(1.01,5.13)**
60+ years	0.60	(0.26,1.39)	1.16	(0.51,2.61)	**2.27**	**(1.08,4.76)**
SES[2]						
High	1.0 (Ref)		1.0 (Ref)		1.0 (Ref)	
Medium	0.93	(0.28,3.04)	0.39	(0.15,1.03)	0.46	(0.14,1.57)
Low	1.00	(0.29,3.40)	0.77	(0.33,1.79)	0.68	(0.24,1.91)
Urban (vs rural)	0.58	(0.23,1.43)	0.99	(0.38,2.59)	1.66	(0.81 , 3.40)
BMI ≥25	0.51	(0.23, 1.14)	0.86	(0.36 , 2.05)	0.66	(0.35 , 1.26)
Hypertension[3]	0.58	(0.27, 1.28)	1.21	(0.48 , 3.06)	1.48	(0.74 , 2.99)
High LDL cholesterol[4]	0.58	(0.29, 1.15)	0.73	(0.39 , 1.37)	1.03	(0.69 , 1.53)

Note:
[1]Multinomial logistic regression was used where the outcome was a 4-level categorical variable: undiagnosed (i.e. in the all diabetes group), diagnosed, on treatment, controlled. Each model controlled for region, one of the above covariates of interest, and weighted for complex survey design.
[2]SES was calculated using a version of the Graffar Scale modified for Venezuela, which combines income, profession, educational level, and housing conditions into a composite score.
[3]Overweight BMI was modelled as a binary variable (≥25.0 kg/m^2 vs <25 kg/m^2)
[4]Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.
[5]High LDL cholesterol was defined as LDL of ≥100 mg/dL

Longitudinal Analyses

In the longitudinal sample of 210 participants with diabetes providing data in baseline and follow-up, most were female, above 60 years of age, had low SES, and lived in urban areas (**Table 4.2**). Most of these participants also had overweight/obesity, hypertension, and high LDL cholesterol. Between 2014-2017 and 2018-2020, 76% of participants experienced percent body weight gain, 9% had no percent body weight change and 15% experienced percent body weight loss. In 2014-2017, 83% of participants with diabetes who were on treatment were taking oral antidiabetic medications only, 8% were taking insulin only, and 9% were taking a combination. This remained similar in 2018-2020: 81% were taking oral medications only, 7% were taking insulin only, and 12% were taking both. Mean HbA1C (based on fasting blood glucose equivalents) in our sample was 5.3% [Standard Deviation (SD): 1.07 in 2014-2017 and 5.27% (SD: 1.26) in 2018-2020.

Table 4.2: Baseline sociodemographic and clinical characteristics of Venezuelan adults with diabetes during study period 2014-2020, unweighted

	Total		Male		Female		
	n	%	n	%	n	%	P-value[1]
Overall	210	100	68	34%	142	66%	
Age							0.647
<50 years	35	17%	13	19%	22	15%	
50-59 years	57	27%	16	24%	41	29%	
60+ years	118	56%	39	57%	79	56%	
SES[2]							0.607
High	27	13%	11	16%	16	11%	
Medium	60	29%	19	28%	41	29%	
Low	123	59%	38	56%	85	60%	
Urban	166	79%	55	81%	111	78%	0.651
BMI ≥25	163	78%	50	75%	113	80%	0.367
Hypertension[3]	133	63%	43	63%	90	63%	0.984
High LDL cholesterol[4]	119	57%	39	57%	80	56%	0.890

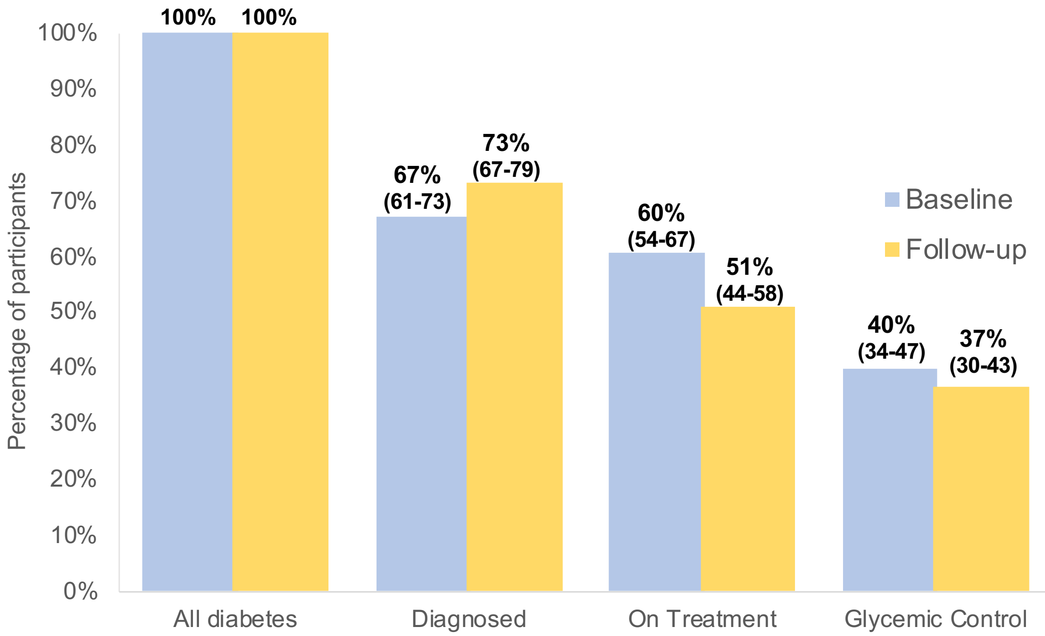
Note: These participants had diabetes and were in the longitudinal sample, i.e. had data for baseline (2014-2017) and follow-up measurements (2018-2020).
[1]P-values calculated using chi-squared tests

[2] SES was calculated using a version of the Graffar Scale modified for Venezuela, which combines income, profession, educational level, and housing conditions into a composite score**.**
[3]Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.
[4]High LDL cholesterol was defined as LDL of ≥100 mg/dL

Supplementary Figure A4.3 summarizes the differences between Venezuelan adults with diabetes lost to follow-up and those retained in the study. Those lost to follow-up were more likely to be male, <50 years old, high or medium SES, and to live in urban areas. Approximately 18% (375 of 2106) of participants lost to follow up had diabetes, compared to 16% (210/1,296) of the longitudinal population.

Among 210 Venezuelan adults with diabetes, the proportion of participants who were diagnosed increased between 2014-2017 and 2018-2020 [67% (95% CI: 61-73) to 73% (67-79), p<0.01), while the proportion of participants who were on treatment decreased significantly [60% (54-67) to 51% (44-57), p<0.01] (**Figure 4.2**). There was a small decrease in the proportion of participants who achieved glycaemic control, though not statistically significant [40% (34-46) to 37% (30-43), p=0.41]. In both 2014-2017 and 2018-2020, the largest proportions of participants were lost at the diagnosis stage (33% and 27%, respectively). In 2018-2020, there were also 22% of patients lost to care between diagnosis and treatment, versus only 7% in 2014-2017.

Figure 4.2: Longitudinal simplified continuum of care among 210 Venezuelan adults with diabetes, Baseline (2014-2017) & Follow-up (2018-2020)



Note: Estimated proportions and 95% confidence intervals. Paired two sample t-tests were used to compute statistical differences between numbers of participants in each step at follow-up compared to baseline. $P<0.01$ for diagnosed and on treatment, $p=0.4$ for achieving glycaemic control.

Table 4.3 shows how many participants switched from one continuum step to another and how many participants remained in the same position. Overall, 50 participants worsened (24%), 40 improved (19%), and 120 stayed the same (57%). Most participants whose continuum stage remained unchanged between study visits were either undiagnosed and remained undiagnosed over time (56 of 210) or achieved glycaemic control and maintained glycaemic control over time (44 of 210). Of the remaining 84 participants who achieved glycaemic control in 2014-2017, 17 (20%) were no longer in control, and 23 (27%) were no longer on treatment in 2018-2020. Of 43 participants on treatment in 2014-2017, 22 (52%) achieved glycaemic control, 11 (26%) remained on treatment, and 10 (23%) were no longer on treatment in 2018-2020.

Table 4.3: Care stage dynamics among 210 Venezuelan adults with diabetes, Baseline (2014-2017) & Follow-up (2018-2020)

		Follow-up			
		Undiagnosed	Diagnosed	On Treatment	Control
Baseline	Undiagnosed	**56**	5	2	6
	Diagnosed	0	**9**	0	5
	On Treatment	0	10	**11**	22
	Control	0	23	17	**44**

Note: Bolded values indicate no change between baseline and follow-up.

When examining sociodemographic and clinical associations with the longitudinal care continuum, participants who had high LDL cholesterol at baseline were less likely to regress along the care continuum than those with lower LDL cholesterol [RRR (95% CI), 0.39 (0.20, 0.77)]. No other significant associations were observed (**Table 4.4**).

Table 4.4: Relative Risk Ratios of Change in Position in Simplified Continuum between Follow-up and Baseline among 210 Venezuelan adults 2014-2020, Unweighted Multinomial Analyses

Covariate of interest	Worsened vs No change		Improved vs No change	
	RRR	(95% CI)	RRR	(95% CI)
Female (vs Male)	0.92	(0.46, 1.86)	1.21	(0.55, 2.67)
Age				
<50	1.0 (Ref)		1.0 (Ref)	
50-59	1.11	(0.40, 3.05)	2.76	(0.79, 9.60)
60+	1.00	(0.41,2.44)	1.64	(0.50, 5.34)
SES[1]				
High	1.0 (Ref)		1.0 (Ref)	
Medium	0.40	(0.14, 1.16)	1.02	(0.24, 4.32)
Low	0.62	(0.24,1.56)	1.61	(0.42, 6.17)
Urban	1.06	(0.45, 2.48)	0.54	(0.22, 1.34)
Overweight BMI[2]	0.86	(0.40, 1.85)	1.89	(0.67, 5.36)
Hypertension[3]	1.20	(0.60, 2.37)	1.65	(0.74, 3.64)
High LDL cholesterol[4]	**0.39**	**(0.20, 0.77)**	0.70	(0.33, 1.47)

Note: Multinomial logistic regression was used where the outcome was a 3-level categorical variable. Participants were given a score at both baseline and follow-up based on their position on the continuum (1 for all diabetes, 2 for diagnosed, 3 for on treatment, and 4 for controlled). The difference between the two scores was calculated and then separated into three categories: worsened, stayed the same, or improved. Each model controlled for region and one of the above covariates of interest. These models include participants who were included in the follow-up measurements and had diabetes at baseline or follow-up.
[1]SES was calculated using a version of the Graffar Scale modified for Venezuela, which combines income, profession, educational level, and housing conditions into a composite score.
[2]Overweight BMI at baseline was modelled as a binary variable ($\geq$25.0 kg/m^2 vs <25 kg/m^2)
[3]Hypertension at baseline was defined as having a systolic blood pressure $\geq$140 mm Hg, diastolic blood pressure $\geq$90 mm Hg, or self-report of antihypertensive medication use.
[4]High LDL cholesterol at baseline was defined as LDL of $\geq$100 mg/dL

Discussion

This study is among the first longitudinal analysis of health system performance for diabetes management and the first continuum of diabetes care applied to Venezuela. The proportion of people with diagnosed diabetes who were on treatment declined over time, from 60% to 51%. Nonetheless, even in 2018-2020, after over five years of political and economic upheaval, half of people diagnosed with diabetes were treated and nearly two out of five had achieved glycaemic control.[123] These proportions are higher than an analysis of 28 LMICs, which found just 38% of people diagnosed with diabetes were currently treated and 23% had achieved glycaemic control.[123] Multinational entities, such as the World Health Organization in their Global Diabetes Compact, should explore the possibility that care requirements in humanitarian emergencies may be distinct from LMICs and programs to improve care need to be adapted to existing infrastructure and human resources.[136]

While treatment rates were lower for this national sample of people with diabetes in Venezuela in 2018-2020 than for the same individuals in 2014-2017, glycaemic control was not substantially different. These findings do not align with previous reports documenting the collapse of the Venezuelan health system, in which medical facilities lack water, electricity, and vital medications.[42,106,137] This counterintuitive observation may be explained by large investments in primary and chronic care in Venezuela only a few years before the crisis,[35] flow of medicines and remittances sent from Venezuelan migrants to their families remaining in country – reportedly reaching 3.7 billion US$ in 2019[138] – and the fact that the majority of participants with diabetes were not insulin dependent. One possible explanation, change in diet and increase in physical activity, has been ruled out as only 15% of EVESCAM participants experienced percent weight loss and a previous analysis found that diet consisted mostly of high calorie staples such as arepas and cheese.[99] However, EVESCAM treatment data were binary and did not include further details such as in quality, dosage and frequency.

Previous literature on diabetes management in crises underscore the complexity of disease care in these settings. A number of small, longitudinal studies have documented mean HbA_{1C} increasing after both natural disasters[26,27,30] and war.[28,32] However, the relationship between exposure to crisis and increased A1C is not always uniform among the entire population. For example, a study of individuals displaced by Hurricane Katrina documented a drop in A1C levels only among publicly insured individuals with diabetes, but no change among individuals with diabetes who had private or Veteran Affairs insurance.[30] Another study of 296 people with diabetes during the Hull, England flooding of 2008 only documented A1C decreasing among insulin-treated participants.[27] One study of Sarajevans during the Balkan wars in the early 1990s documented a decrease in A1C levels among people with diabetes from before the war to three years into the war, though this phenomenon was attributed to decreased BMI.[29] Finally, a study of Croatians during the Balkan wars documented no difference in mean A1C among 35 people with diabetes examined before the war and again three months after the war began.[31] None of these studies visualized diabetes management using the continuum of care framework, instead they quantified quality of diabetes management using mean A1C levels.[26-32]

For comparison, mean HbA1C in our sample remained unchanged between 2014-2017 and 2018-2020.

Previous care continua for diabetes have focused either entirely on LMICs[123,127-131] or high-income settings.[124] Manne-Goehler et al., for example, conducted a cascade of diabetes care study of 28 LMICs in multiple geographic regions,[123] and found only 6% of participants to be lost between diagnosis and treatment, a stark difference from the 20% reported here. While the gap between treatment and any glycaemic control in Venezuela was similar to the aggregated average for 28 LMICs, Venezuela had high proportions for both steps: 51% on treatment dropped to 32% for achieving any glycaemic control compared to 38 to 23% among 28 LMICs. Unlike the present study, which found few differences in change of care continuum position by sociodemographic subgroup, Manne-Goehler et al. found stark differences by subgroup. Specifically, individuals who were older, had higher educational attainment, and had higher BMI had higher odds of being tested, on treatment, and achieving glycaemic control.[123] In our nationally representative analysis for 2014-2017, older age and female sex were marginally associated with increased likelihood of achieving glycaemic control. Additionally, older age and medium SES (compared to high SES) were associated with increased likelihood of being on treatment. Our results suggest that the decline in treatment rates among people diagnosed with diabetes in Venezuela did not differ by SES, urban residence, or age, similarly affecting all population subgroups.

There are several limitations to this study. First, the EVESCAM study experienced high loss-to-follow-up between baseline and follow-up, at 65%. This is expected considering mass emigration and movement within the country. As of June 2021, over 5.6 million Venezuelans had fled their country[33] and there remains no reliable estimates for internal displacement, though the Internal Displacement Monitoring Centre suggest that a displacement crisis is likely based on cross-border movement and conditions inside the country.[139] As shown in **Supplemental Table 4.2**, the largest subgroups lost to follow-up in EVESCAM were younger men who had high SES and lived in cities. Therefore, the estimates presented in this paper are representative of those who stayed, a population that is more likely to be female, lower SES, and rural. Also, our definition of glycaemic control was based on only one blood glucose measurement at each time point rather than A1C, which measures the average glucose levels over the course of red blood cells lifespan (approximately 40-60 days).[140] We calculated A1C levels post hoc using the fasting blood glucose measurement, which may have introduced some inaccuracy for prevalence estimates.[140] Finally, two stages of the care continuum – diagnosis and treatment – were based on self-report and could not be confirmed with medical records.

Despite these limitations, EVESCAM is among the first studies to gather longitudinal data in the middle of a crisis in the same individuals and the first in Venezuela to collect nationally representative data on NCD risk factors based on biomarkers for diabetes and clinical measurements of important comorbidities (e.g. blood pressure and cholesterol). Although 35% retention seems low for typical epidemiological surveys, this was a remarkable feat for a field-based study in a crisis setting experiencing mass migration. In general, the EVESCAM study offers a unique window into a country that rapidly shifted from high to low resources over a short period of time.

These results show a surprisingly high proportion of individuals living with diabetes that are regularly accessing treatment and maintaining glycaemic control. Further study is needed to understand how these individuals were so resilient in time of crisis, to better inform strategies for other settings where health care systems are less successful to provide care for chronic diseases. Understanding barriers and facilitators to NCD management in crisis is particularly relevant amid the COVID-19 pandemic, as underlying chronic conditions such as diabetes are risk factors for severe disease and as health systems worldwide are facing catastrophic disruptions.

Chapter 5: Conclusion

In this dissertation, we used a variety of quantitative methods to describe and document the state of NCD care in Venezuela among individuals who were not displaced. Each of the three studies serve the goal of better understanding cardiometabolic disease risk and burden in Venezuela by 1) documenting dietary risk factors in Venezuela, 2) comparing cardiometabolic multimorbidity burden in Venezuela with Mexico and Hispanics in the US, and 3) examining changes in diabetes management throughout the humanitarian crisis in Venezuela.

Specifically, in Chapter Two, we looked at dietary risk factors for cardiometabolic diseases and found that dietary diversity among Venezuelans in 2014-2017 was very low: on average, people consumed just two food groups daily with the primary food groups consumed being white bread and arepas (a salted corn cake). In Chapter Three, we compared nationally representative cardiometabolic multimorbidity prevalence and patterns in Venezuela, US Hispanics, and Mexico and found that even during a humanitarian crisis, the multimorbidity prevalence in Venezuelans who remained in their homes was lower than that of Hispanics in the US. Finally, in Chapter Four, we found that the proportion of EVESCAM participants with diagnosed diabetes who were on treatment declined over time, from 60% to 51%. However, even in 2018-2020, after over five years of political and economic upheaval, half of people in our sample with diagnosed diabetes were treated and nearly two out of five had achieved glycemic control.

Strengths and Limitations

This dissertation has a number of strengths. First, EVESCAM is the first nationally representative study of cardiometabolic diseases and their risk factors in Venezuela, providing much-needed data in a country undergoing a sociopolitical crisis and that has not published publicly available health statistics since 2016. The majority of reports from inside Venezuela have been from humanitarian aid, advocacy, and news media sources which have shed valuable light on the situation in the country, but not at the population-level. EVESCAM provides key epidemiological evidence with a high response rate at baseline, standardized questionnaires conducted by trained field workers, and objective clinical measurements utilizing validated laboratory tests. What little work that has been done in this space has focused on displaced individuals, such as refugees, migrants, and IDPs, but this dissertation focuses on those who remained in their homes during the crisis.

Second, this dissertation compares EVESCAM baseline data with two other country's nationally representative surveys to contextualize the burden of multimorbidity in Venezuela with Mexico and Hispanics living in the US, and to understand population-level correlates of multimorbidity in three settings with large populations, high NCD burdens, and close cultural ties.

Lastly, this dissertation conducts longitudinal analyses of EVESCAM data. EVESCAM remains among the first studies to gather longitudinal data in the middle of a crisis in the same individuals. The EVESCAM investigators achieved a remarkable feat by conducting a field-based study in a crisis setting experiencing mass migration. Moreover, analyzing the EVESCAM dataset offered a unique window into a country that rapidly shifted from high to low resources over a short period of time. This dissertation highlights the difficulties of conducting population surveys during political crisis, including ethical ramifications of participant burden among a population undergoing profound stress. Simultaneously, this work underscores the importance of collecting such data when other data sources, such as government health statistics, are unreliable or non-existent.

Nonetheless, this dissertation has several limitations. The EVESCAM study experienced high loss-to-follow-up between baseline and follow-up, at 65%. This was not surprising considering mass emigration and movement within the country. As of June 2021, over 5.6 million Venezuelans had fled their country[33] and there remains no reliable estimates for internal displacement, though the Internal Displacement Monitoring Centre suggests that a displacement crisis is likely based on cross-border movement and conditions inside the country.[139] As such, this analysis is only able to make observations about the population that stayed in Venezuela.

Also, for all three chapters, cardiometabolic indicators were based on a single measure which might overestimate prevalence among undiagnosed participants due to aberrant fasting or lab issues. For example, diabetes diagnoses were based on only one blood glucose measurement rather than multiple. Despite this limitation, a single clinical measure provides more information and is more valid than only relying on self-report of previous diagnoses. Furthermore, throughout this dissertation, the diabetes definition does not definitively rule out type 1 diabetes cases, but globally over 95% of diabetes cases are T2D.[80] Moreover, in baseline EVESCAM, only 7% of participants were on insulin and the average age of diabetes diagnosis was 50.6 years, so this was unlikely to be a major source of error in this analysis.

Furthermore, EVESCAM was not designed to make causal statements about the impact of humanitarian crises on NCD health, but rather to estimate prevalence of cardiometabolic diseases and their risk factors in Venezuela. As a result, this dissertation cannot claim causality regarding the effect that the humanitarian crisis in Venezuela had on disease prevalence or management. Instead, it aims to fill a dearth of scientific evidence on documenting the current state of NCDs in Venezuela among individuals who were not displaced.

Finally, this observational study introduced opportunities for reverse causation, particularly among individuals who are aware of their cardiometabolic conditions and may have changed their behaviors based on their diagnosis. This appeared in Chapter 2, where we found individuals with hypertension, diabetes, and obesity consumed red meat, arepas, and soft drinks less frequently, and again in Chapter 3, where we found certain behavioral risk factors for multimorbidity (such as consumption of fruit and vegetables) appeared to have no association with odds of multimorbidity.

Implications

These papers display three different applications of observational data analysis to describe a population that is understudied and explain possible associations between cardiometabolic health status and independent variables of interest. However, this dissertation is only the first step, and much more work is needed to understand the role crises play in NCD management.

Venezuela provides a case study for a country whose economic prosperity and progress along the epidemiological and nutritional transition collapsed due to political turmoil. In the coming years, climate disasters might overwhelm the healthcare institutions and humanitarian capacities of island nations faster than the political and economic crisis has in Venezuela, but researchers, humanitarian aid organizations, and local governments can collaborate to learn from previous situations. The crisis in Venezuela has been further complicated by the COVID19 pandemic, which put further stress on the health system. Future studies from the EVESCAM team might consider focusing on migrant populations in neighboring Colombia and Trinidad and Tobago to better understand the role NCD management plays in driving migration. Unanswered questions remain regarding the healthy migrant theory: are those with NCDs less likely to emigrate from Venezuela due to their chronic health conditions? Or are they more likely to emigrate to ensure continuous access to their essential medications?

Future surveillance of the Venezuelan population should also include indicators from standardized and widely used questionnaires. This would facilitate better comparisons between Venezuelans in country, Venezuelan migrants in other countries, and host populations. In particular, these comparisons would help explain the resilience documented among Venezuelans with diabetes in EVESCAM, who maintained high rates of glycemic control despite the crisis. Strengthening the indicators used would also shed light on how other chronic diseases, such as mental health and respiratory illnesses, are managed in humanitarian settings.

The EVESCAM team conducted high-quality surveillance in a challenging setting and under an authoritarian government that actively tried to suppress their research. They have provided countless lessons on the determination and flexibility necessary to collect epidemiologic data, including but not limited to, changing sampling strategies to stretch limited funding, and retaining staff members during a period of high migration and stress.

As previously established, humanitarian crises are projected to increase in frequency and duration, so the global health community must consider how NCD interventions should be delivered in emergency settings and humanitarian organizations should continue to grow capacity for NCD aid. However, these interventions must be based in rigorous epidemiologic evidence highlighting the burden of disease and pathways for intervention. As such, future research should be designed to understand how crisis affects risk factors for medication access, disease management, and multimorbidity prevalence.

This dissertation provides results that are most generalizable to settings that have existing high NCD burdens, such as island nations or upper-middle income countries at risk of political unrest, war or natural disasters. Though the Venezuelan crisis is inherently political and "man-made," the situation unfolded quickly and transformed an upper-middle income country to experiencing food insecurity. With climate change, the rise of populist authoritarians, and the destabilization of global financial markets, middle income states are becoming increasingly fragile and their capacity to respond to future emergencies requires generalizable findings on how NCD care is affected by the sudden collapse of healthcare institutions. From Venezuela to Ukraine, populations previously accustomed to managing chronic illnesses such as diabetes are suddenly food-insecure, unsure of how and when they will access life-saving medications, and faced with stressful, traumatic decisions regarding migration and violence.

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Appendix

Chapter 2 Appendices

Table A2.1: Dietary Intake Questionnaire

FOOD GROUP	Please check the food list below. If you eat these foods, compare the amount you eat with the serving size shown in the photo, and report how many servings you typically consume in a day, week or month according to the case. You will be guided by a trained staff.								
		one	**2 to 4**	**5 or more**	**one**	**2 to 4**	**5 or more**	**0**	**1 to 3**
Fruits 1. Whole or chopped fruit	1 medium unit 1 large cup (240 cc) of chopped fruit								
2. Fruit juice	1 glass of fruit juice (200 cc)								
3. **Vegetables** (ask salads)	- Raw: 1 large cup (8 ounces = 240 cc) - Cooked: ½ large cup								
Dairy products and derivatives: 4. Milk and whey	- Milk: 1 glass (200 cc) - Whey: 1 small glass (180 cc)								
5. Cheeses	- 1 slice (30 g) - 3 tablespoons (30 g, that is 10 g per unit)								
6. **Fats** (butter, margarine, milk cream, oil)	- Butter, margarine, mayonnaise and cream of milk: 1 tablespoon (15 g) - Oils: 1 tablespoon (10 cc = 10 g)								
Starches 7. White bread	1 slice of bread = ½ french bread								
8. Arepa	1 medium unit (100 g)								
9. Pasta	1 cup or 1 small plate (150 g)								
10. Cooked white rice	1 cup (125 g)								
12. Cereals	½ cup of flakes								
13. Boiled yuca and / or casava	- Yucca: 1 medium piece (150 g) - Casabe: ¼ medium cake								
14. Whole potato or mashed	1 small potato (50 g) = ½ cup of mash								
15. Plantain	Medium plantain								
Whole grains 16. Prepared flaked oatmeal	½ cup cooked								
17. Stacked corn cachapa	½ small cachapa (80 g)								
18. **Legumes** (beans, lentils, vetch, etc.)	1 cup cooked (210 g)								
19. **Soups** (not including legumes)	1 cup (240 g)								

Table A2.1: (Continued)

20. **Nuts and seeds** (nuts, peanuts, pistachios, hazelnuts, almonds)	½ cup or 3 tablespoons (25 g)								
21. **Fish** (include sardine and canned tuna)	- Fish: 1 medium steak (120 g) - Sardine and tuna: 1 drained can (120 g)								
22. **Poultry** (Chicken, chicken)	- Chicken: 1 breast or 2 thighs (120 g)								
24. **Eggs**	1 unit (50 g)								
25. **Meats**	1 medium steak (120 g)								
Fried food 26. Empanadas	1 medium unit (80 g)								
27. French fries	½ cup (68 g)								
Fried banana slices or tostones	Slice: ½ banana = 4 units (150 g) Tostones ½ banana = 4 units (150 g)								
28. Fast food Burgers Hot dogs Pepitos (tenderloin sandwich) Pizzas	1 small unit (102 gr) or 1 pc. 1 medium unit (medium Frankfurt sausage = 30 g) a. ½ unidad de ½ pan canilla = ¼ pan canilla b. ½ unit of ½ bread quill = ¼ bread quill ½ small pizza								
29. Sweet or savory cookies	- Sweet cookie: 1 package (30 g) - Soda cookie: 1 package								
30. Cakes or desserts	- Sweets and desserts: ½ cup = 1 ounce (33 g)								
31. Sugar	1 tablespoon = 15 g 1 teaspoon = 5 g								
32. Meals in Fast Food Sales (include franchises and street shops)	Write down the number of times the subject eats in those establishments								
33. **Beverages** (Soft drinks and instant drinks like cold tea)	1 glass = 240 cc = 8 ounces = 1 bottle								
34. **Water**	1 glass = 240 cc = 8 ounces								
35. **Alcohol**	Beer (360cc = 1 and a half) Wine (150 cc = 1 glass) Whiskey, rum and others (1.5 ounces = 45 cc)								
36. **Coffee**	Coffee = 1 medium cup								

Figure A2.1: Example Show Cards Used in the EVESCAM Study

1

EVESCAM - SVMI - FISPEVen

2

3

EVESCAM - SVMI - FISPEVen

4

EVESCAM - SVMI - FISPEVen

Table A2.2: Food Categories Used for Dietary Diversity Score

Food Category for MDD-W	**Food Group in EVESCAM DDS**
Grains, white roots and tubes, plantains	White bread, pasta, cereal, oats, rice, potato, plantain, yucca
Pulses	Legumes
Nuts & Seeds	Nuts
Dairy products	Milk, cheese
Animal-based foods	Fish, poultry, red meat, hamburgers
Eggs	Eggs
Other Fruits	Fruit
Vitamin-A rich fruits	
Other Vegetables	Vegetables
Leafy green vegetables	

Table A2.3- Missing data among 3,402 individuals included in analysis

Variable	Number missing	Percent Missing
Age	0	0
Sex	0	0
SES	48	1.41
Rural/Urban Residence	0	0
BMI	14	0.41
Diabetes	11	0.32
Hypertension	1	0.03

Chapter 3 Appendices

Table A3.1- Missing data for covariates among 6,935 individuals included in analysis

Covariate	Number missing	Percent Missing
Age	0	0
Sex	0	0
Education	61	0.8
Daily fruit and vegetable consumption	0	0
Smoking status	126	1.82
Alcohol consumption	228	3.29
Physical Activity	297	4.28

Table A3.2.1: Disease Patterns (Cardiometabolic diseases) among Venezuelans

Disease Combination	%	(95% CI)	
Hypertension + Obesity	10.64	9.14	12.35
T2D + Hypertension	7.23	6.01	8.66
Hypertension + High LDL	6.67	5.14	8.62
T2D + Obesity	4.62	3.78	5.63
High LDL + Obesity	3.72	2.89	4.77
T2D + High LDL	3.16	2.31	4.32
T2D + Hypertension + Obesity	2.47	2.00	3.04
Hypertension + High LDL + Obesity	2.38	1.76	3.21
T2D +Hypertension + High LDL	2.23	1.62	3.05
ACVE + Hypertension	2.02	1.70	2.41
T2D + High LDL + Obesity	1.24	0.78	1.95
ACVE + Obesity	0.90	0.66	1.22
T2D + ACVE	0.86	0.65	1.14
ACVE + high LDL	0.73	0.51	1.03
T2D + ACVE + Hypertension	0.73	0.52	1.01
ACVE + Hypertension + high LDL	0.52	0.34	0.79
ACVE + Hypertension + Obesity	0.51	0.34	0.78
T2D + ACVE + High LDL	0.27	0.15	0.48
ACVE + High LDL Obesity	0.21	0.11	0.40
T2D + ACVE + Obesity	0.15	0.08	0.27

Table A3.2.2: Disease Patterns (Cardiometabolic diseases) among Mexicans

Disease Combination	%	95% CI	
Hypertension + Obesity	9.19	7.51	11.21
T2D + Obesity	6.23	4.90	7.89
T2D + Hypertension	5.81	4.51	7.45
High LDL + Obesity	5.24	3.72	7.35
Hypertension + High LDL	4.73	3.31	6.71
T2D + Hypertension + Obesity	3.37	2.49	4.55
T2D + High LDL	2.77	1.88	4.04
Hypertension + High LDL + Obesity	2.51	1.63	3.84
T2D + Hypertension + High LDL	2.00	1.25	3.18
T2D + High LDL + Obesity	1.61	0.96	2.70
ACVE + Hypertension	0.97	0.52	1.81
ACVE + Obesity	0.97	0.53	1.78
ACVE + Hypertension + Obesity	0.77	0.37	1.62
ACVE + High LDL	0.65	0.32	1.34
ACVE + Hypertension + High LDL	0.54	0.23	1.26
ACVE + High LDL Obesity	0.49	0.20	1.16
T2D + ACVE	0.40	0.20	0.81
T2D + ACVE + Hypertension	0.35	0.16	0.75
T2D + ACVE + Obesity	0.27	0.11	0.66
T2D + ACVE + High LDL	0.25	0.10	0.65

Table A3.2.3: Disease Patterns (Cardiometabolic diseases) among US Hispanics

Disease Combination	%	95% CI	
Hypertension + Obesity	14.06	11.91	16.52
T2D + Obesity	10.35	8.55	12.47
Hypertension + High LDL	9.46	7.64	11.66
High LDL Obesity	8.70	7.30	10.34
T2D+ Hypertension	8.57	7.03	10.42
T2D + High LDL	7.75	6.38	9.38
T2D + Hypertension + Obesity	5.32	4.07	6.92
Hypertension + High LDL + Obesity	5.07	3.77	6.79
T2D + Hypertension + High LDL	4.53	3.66	5.59
T2D + High LDL Obesity	4.47	3.50	5.69
ACVE + Hypertension	2.41	1.64	3.54
ACVE + High LDL	1.96	1.38	2.77
ACVE + Obesity	1.87	1.30	2.68
T2D + ACVE	1.42	0.80	2.51
ACVE + Hypertension + High LDL	1.31	0.91	1.88
ACVE + Hypertension + Obesity	1.30	0.87	1.96
T2D + ACVE + Hypertension	1.09	0.57	2.07
ACVE + High LDL Obesity	1.02	0.69	1.51
T2D + ACVE + High LDL	0.96	0.58	1.58
T2D + ACVE + Obesity	0.63	0.32	1.23

Table A3.3.1 – Disease Patterns (Cardiometabolic diseases + Depression) among Venezuelans

Disease Combination	%	95% CI	
		LB	UB
HTN + Obesity	10.64	9.14	12.35
HTN + T2D	7.23	6.01	8.66
HTN + High LDL	6.67	5.14	8.62
T2D + Obesity	4.62	3.78	5.63
highLDL + Obesity	3.72	2.89	4.77
T2D + High LDL	3.16	2.31	4.32
T2D + HTN + Obesity	2.47	2.00	3.04
HTN + High LDL + Obesity	2.38	1.76	3.21
T2D + _HTN + High LDL	2.23	1.62	3.05
ACVE +HTN +	2.02	1.70	2.41
Depression_HTN +	1.36	1.01	1.85
T2D + High LDL +Obesity	1.24	0.78	1.95
ACVE + Obesity	0.90	0.66	1.22
ACVE + T2D	0.86	0.65	1.14
ACVE + High LDL	0.73	0.51	1.03
ACVE +T2D + HTN	0.73	0.52	1.01
Depression + Obesity	0.60	0.40	0.91
ACVE + HTN + High LDL	0.52	0.34	0.79
ACVE + HTN + Obesity	0.51	0.34	0.78
T2D + Depression	0.49	0.28	0.85
Depression + High LDL	0.44	0.28	0.69
T2D + Depression + HTN	0.37	0.22	0.65
Depression + HTN + High LDL	0.29	0.15	0.56
Depression + HTN + Obesity	0.28	0.15	0.52
ACVE + T2D + High LDL	0.27	0.15	0.48
ACVE + High LDL + Obesity	0.21	0.11	0.40
ACVE + Depression	0.15	0.07	0.33
ACVE + T2D + Obesity	0.15	0.08	0.27
ACVE + Depression + HTN	0.14	0.06	0.32
T2D + Depression + Obesity	0.14	0.07	0.27
Depression + High LDL + Obesity	0.13	0.04	0.39
T2D + Depression + High LDL	0.12	0.06	0.27
ACVE +T2D + Depression	0.09	0.02	0.32
ACVE + Depression + High LDL	0.02	0.01	0.08
ACVE + Depression + Obesity	0.02	0.00	0.06

Table A3.3.2 – Disease Patterns (Cardiometabolic diseases + Depression) among US Hispanics

Disease Combination	%	95% CI LB	95% CI UB
HTN + Obesity	14.06	11.91	16.52
Depression + Obesity	12.30	10.25	14.70
T2D + Obesity	10.35	8.55	12.47
HTN + High LDL	9.46	7.64	11.66
High LDL + Obesity	8.70	7.30	10.34
T2D + HTN	8.57	7.03	10.42
T2D + High LDL	7.75	6.38	9.38
Depression + HTN	7.12	5.48	9.19
T2D + HTN + Obesity	5.32	4.07	6.92
Depression + High LDL	5.16	3.99	6.65
HTN + High LDL+ Obesity	5.07	3.77	6.79
T2D + HTN + High LDL	4.53	3.66	5.59
T2D + High LDL+ Obesity	4.47	3.50	5.69
Depression + HTN + Obesity	4.23	3.15	5.66
T2D + Depression	4.14	3.15	5.43
Depression + High LDLObesity	2.97	2.08	4.23
T2D + Depression +Obesity	2.79	1.89	4.09
Depression + HTN + High LDL	2.65	1.75	3.99
ACVE + HTN	2.41	1.64	3.54
T2D + Depression + HTN	2.41	1.72	3.37
T2D + Depression + High LDL	2.18	1.47	3.21
ACVE + High LDL	1.96	1.38	2.77
ACVE + Depression	1.92	1.03	3.54
ACVE + Obesity	1.87	1.30	2.68
ACVE + T2D +	1.42	0.80	2.51
ACVE + HTN + High LDL	1.31	0.91	1.88
ACVE + HTN + Obesity	1.30	0.87	1.96
ACVE + T2D + HTN	1.09	0.57	2.07
ACVE + Depression + HTN	1.03	0.54	1.93
ACVE + High LDL + Obesity	1.02	0.69	1.51
ACVE + T2D + High LDL	0.96	0.58	1.58
ACVE + Depression +Obesity	0.86	0.46	1.61
ACVE + Depression + High LDL	0.73	0.50	1.08
ACVE + T2D + Obesity	0.63	0.32	1.23
ACVE + T2D + Depression	0.53	0.27	1.05

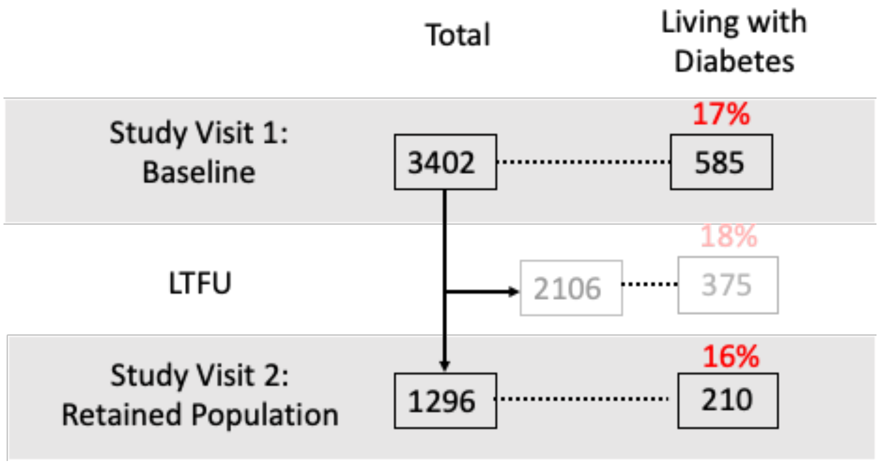
Table A3.6 –Stratified multivariate logistic regression analyses assessing multimorbidity of cardiometabolic diseases[1] + depression[2] multimorbidity, Venezuela (2014-2017)

	OR	(95% CI)
Male	0.95	(0.74, 1.22)
Age category		
<35		1.0 (Ref)
35-44	2.92	(2.0, 4.28)
45-54	5.15	(3.30, 8.04)
55+	9.47	(6.58, 13.63)
Education[5]		
Low		1.0 (Ref)
Medium	0.82	(0.61, 1.09)
High	0.73	(0.50, 1.05)
Daily fruit and vegetable intake[6]		
None		1.0 (Ref)
Once daily	0.97	(0.78, 1.21)
2-4 daily	1.12	(0.80, 1.56)
5+ daily	0.62	(0.35, 1.09)
Smoking		
Never		1.0 (Ref)
Past	1.28	(0.97, 1.70)
Current	0.95	(0.61, 1.49)
Alcohol Use		
Not currently drinking		1.0 (Ref)
Less than daily drinker	0.92	(0.79, 1.07)
Daily drinker	0.42	(0.15, 1.16)
Physical Activity[8]		
Low		1.0 (Ref)
Moderate	0.80	(0.64, 0.99)
High	0.63	(0.46, 0.87)

Table A3.7 – Stratified multivariate logistic regression analyses assessing multimorbidity of cardiometabolic diseases[1] + depression[2] multimorbidity, US Hispanics (2015-2016 & 2017-2018)

	OR	(95% CI)
Male	0.74	(0.56, 0.98)
Age category		
<35	1.0 (Ref)	
35-44	2.15	(1.38, 3.35)
45-54	5.72	(3.84, 8.52)
55+	9.86	(6.13, 15.87)
Education[5]		
Low	1.0 (Ref)	
Medium	0.93	(0.62, 1.39)
High	0.75	(0.53, 1.06)
Daily fruit and vegetable intake[6]		
None	1.0 (Ref)	
Once daily	1.55	(1.02, 2.36)
2-4 daily	1.01	(0.54, 1.88)
5+ daily	0.94	(0.40, 2.22)
Smoking		
Never	1.0 (Ref)	
Past	1.23	(0.80, 1.88)
Current	2.17	(1.36, 3.48)
Alcohol Use		
Not currently drinking	1.0 (Ref)	
Less than daily drinker	1.01	(0.71, 1.44)
Daily drinker	1.42	(0.38, 5.28)
Physical Activity[8]		
Low	1.0 (Ref)	
Moderate	0.93	(0.65, 1.35)
High	1.20	(0.80, 1.80)

Figure A4.1: Participant Flow Chart



The following flow chart shows (1) the total number of participants in the baseline, lost to follow-up (LTFU), and retained populations, (2) what proportion of each population had diabetes, (3) the number of individuals in each population with diabetes. Diabetes was defined as FPG ≥126 mg/dL, 2-hour OGTT ≥200 mg/dL, or self-report of previous diagnosis of diabetes by a clinician.[64]

Table A4.1- Missing baseline & follow-up data included in analysis

Variable	Baseline (2014-2017) n=585		Follow-up (2017-2018) n=210	
	Number missing	Percent Missing	Number missing	Percent Missing
Region	0	0.00	0	0
Age	0	0.00	0	0
SES	12	2.05	0	0
Sex	0	0.00	0	0
BMI	4	0.68	0	0
Hypertension	0	0.00	0	0
LDL cholesterol	2	0.34	0	0
Previous diabetes diagnosis*	0	0.00	0	0
Currently taking any diabetes medication*	158	27.01	61	29.05
Fasting Plasma Glucose	2	0.34	0	0

**Notes*: Missing data were coded as "no" for self-reported indicators due to skip pattern in survey instrument used.

Table A4.2: Baseline sociodemographic and clinical characteristics of 585 Venezuelan adults with diabetes during study period 2014-2017, nationally representative

	Total (n=585)		Male (n=212)		Female (n=373)		
	%	(95% CI)	%	(95% CI)	%	(95% CI)	P-value[1]
Overall			56.6	(51.7, 61.3)	43.4	(38.7, 48.3)	
Age							0.710
<50 years	46.3	(39.6, 53.2)	47.2	(38.4, 56.1)	47.2	(38.4, 56.1)	
50-59 years	22.7	(18.0, 28.1)	22.5	(16.2, 30.4)	22.5	(16.2, 30.4)	
60+ years	31.0	(26.2, 36.3)	30.3	(24.2, 37.2)	30.3	(24.2, 37.2)	
SES[2]							0.395
High	19.9	(14.8, 26.2)	22.2	(15.4, 31.0)	16.9	(11.9, 23.5)	
Medium	28.0	(23.5, 33.1)	28.2	(21.4, 36.1)	27.9	(22.6, 33.9)	
Low	52.0	(45.2, 58.8)	49.6	(39.6, 59.7)	55.2	(48.4, 61.8)	
Urban	81.2	(60.2, 92.5)	79.6	(57.1, 92.0)	77.7	(51.6, 92.0)	0.814
BMI ≥25	73.9	(65.3, 81.0)	74.6	(65.4, 82.0)	71.4	(64.5, 77.5)	0.820
Hypertension[3]	53.9	(47.5, 60.1)	52.0	(42.7, 61.2)	58.0	(50.7, 65.0)	0.507
High LDL cholesterol[4]	59.6	(54.2, 64.8)	59.4	(50.3, 68.0)	64.1	(56.4, 71.2)	0.426

These participants had diabetes and were in the baseline sample, i.e. had data for baseline (2014-2017). Unweighted n and weighted percentages are reported.

[1] P-values calculated using chi-squared tests

[2] SES was calculated using a version of the Graffar Scale modified for Venezuela, which combines income, profession, educational level, and housing conditions into a composite score**.**

[3]Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.

[4]High LDL cholesterol was defined as LDL of ≥100 mg/dL

Table A.4.3: Sociodemographic and clinical characteristics of Venezuelan adults included in total nationally representative population and follow-up with diabetes, at baseline

	Population excluded from Follow-up, at Baseline		Follow-up Population, at Baseline[1]		
	n=365	%	n=210	%	P-value[2]
Female	219	60%	145	70%	0.020
Age					0.046
<40	37	10%	14	6%	
40-49	60	16%	22	10%	
50-59	88	24%	60	27%	
60+	180	49%	123	56%	
SES[2]					0.011
High	72	20%	22	10%	
Medium	96	27%	61	29%	
Low	193	53%	129	61%	
Urban	323	88%	175	80%	0.005
Overweight BMI[3]	269	74%	152	74%	1.000
Hypertension[4]	238	65%	135	65%	0.942
High cholesterol[5]	219	60%	151	73%	0.219

[1]This population only includes individuals who had diabetes during baseline measurements.
[2] P-values calculated using Chi-squared tests.
[3] SES was calculated using a version of the Graffar Scale modified for Venezuela, which combines income, profession, educational level, and housing conditions into a composite score**.**
[4]BMI was defined as weight (measured in kilograms) divided by height (measured in meters) squared and classified as overweight/Obesity (≥25.0 kg/m^2) or underweight/normal weight (<25.0 kg/m^2).
[5]Hypertension was defined as having a systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or self-report of antihypertensive medication use.
[6]High LDL cholesterol (>100 mg/dL)