Neighborhood Socioeconomic Status and Cardiometabolic Outcomes in Urban Jamaica: Exploring Novel Measures

by

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Abstract

Introduction: Diabetes, hypertension, high cholesterol, and obesity are increasingly prevalent in Afro-Caribbean populations. Much remains unknown about the relationship between these cardiometabolic outcomes and neighborhood socioeconomic status (SES). This study explores associations between neighborhood SES and cardiometabolic outcomes in urban Jamaica.

Methods: Data from urban participants (n=833, women 577, men 282) in an ancillary study to the Jamaica Health and Lifestyle Survey 2016-2017 was analyzed to examine associations between neighborhood SES and cardiometabolic outcomes. Median property sales price was obtained from the Jamaica National Land Agency and selected as the primary neighborhood SES measure. Survey-weighted Poisson regression was used to assess prevalence ratios for measured diabetes, hypertension, high cholesterol, and obesity. Neighborhood percentages of educational attainment, dependency ratio, employment, and household state assistance were covariates in adjusted models.

Results: Most participants were aged 45 to 64 (34.9%) and had at least a high school education (77.7%). Men were more likely to be adequately physically active (52.4% vs. 42.0%, p=0.003) and current smokers (29.7% vs. 10.8%, p <0.001). More women had hypertension (53.0% vs. 45.6%, p=0.047), high cholesterol (34.3% vs. 21.7%, p<0.001), and obesity (45.7% vs. 19.4%, p<0.001). Survey-weighted regression showed high neighborhood SES was associated with higher prevalence of hypertension (PR=1.33, p=0.044) and high cholesterol (PR=2.46,

p<0.001) in fully adjusted models unstratified by sex when compared with low SES. Increased obesity was observed for the middle (PR=1.46, p<0.001) and high (PR=1.60, p<0.001) SES tiers. In stratified analyses, high neighborhood SES was associated with more obesity among women (P=1.32, p=0.015) and high total cholesterol among men (PR=4.70, p=0.005). Mid SES was associated with increased hypertension among men (PR=2.02, p=0.024).

Conclusions: Among urban Jamaicans, associations between neighborhood SES and cardiometabolic outcomes appear nonlinear and dependent on sex, individual risk factors, and neighborhood characteristics. Future research incorporating more complex neighborhood SES measures may help elucidate these relationships.

Public Health Significance: Adverse cardiometabolic outcomes disproportionately burden Jamaica and other low- and middle-income countries. A better understanding of neighborhood contributors to these outcomes is essential for developing effective interventions.

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Preface

I would like to acknowledge the researchers of the University of the West Indies who conducted the Lown phase two ancillary study from which data for this essay was obtained, and with whom I had the pleasure of working while conducting my analyses. Thank you, Dr. Trevor Ferguson, Ms. Joette McKenzie, Dr. Novie Younger-Coleman, Dr. Marshall Tulloch-Reid, Mr. Alphanso Blake, and Dr. Ishtar Govia.

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1.0 Introduction

1.1 Overview

Diabetes, hypertension, high cholesterol, and obesity are increasingly urgent public health concerns, particularly in low- and middle-income countries. These cardiometabolic outcomes are often comorbid and increase the risk of cardiovascular disease, which is the leading cause of death globally and in the Caribbean (Rivera-Andrade & Luna, 2014; World Health Organization, 2020a). In addition, the Global Burden of Disease Study (GBP) indicates that the Caribbean faces a disproportionate and growing burden of cardiovascular disease risk factors as the region's populations age and become more urbanized and sedentary (Gallardo-Rincón et al., 2021). However, there is limited research on cardiometabolic outcomes and the socioeconomic risk factors at play among Caribbean populations. Studies of neighborhood-level socioeconomic status (SES) are particularly scarce for the region, though the relationship between lower neighborhood SES and poorer cardiovascular disease risk is well established in the United States, Canada, and Europe (Clark et al., 2009; Pollack et al., 2012). The limited evidence from the Caribbean and other low- and middle-income populations, however, is mixed and suggests a nonlinear relationship (de Mestral & Stringhini, 2017). Further exploration may shed light on the drivers of cardiometabolic outcomes in the region and future steps to address the rising crisis. This study explores the association between measures of neighborhood-level SES and diabetes, hypertension, high cholesterol, and obesity in the context of urban Jamaica.

1.2 The Global Burden of Cardiometabolic Outcomes

1.2.1 Definitions

The cardiometabolic outcomes considered by this study are a constellation of treatable conditions that impair health and elevate risk for cardiovascular disease (American Heart Association, 2021; Tasic & Lovic, 2018; World Health Organization, 2021a). These conditions—diabetes, hypertension, high cholesterol, and obesity—are often considered together in research and clinical practice because of their synergistic relationships and interrelated social determinants. In this paper, "cardiometabolic outcomes" and "cardiometabolic risk factors" are used interchangeably.

Diabetes is a chronic metabolic disorder characterized by high blood-glucose levels and increased cardiovascular disease risk. Common clinical definitions rely on fasting glucose levels of ≥ 126 mg/dL (≥ 7 mmol/L) in repeated tests as an indication of diabetes (Blonde et al., 2022; World Health Organization, 2006). Although type 1 and type 2 diabetes are both associated with increased cardiovascular disease mortality, type 2 diabetes accounts for the vast majority of cases and can often be prevented based on lifestyle and environmental factors, such as those relating to weight, diet, physical activity, and stress (Association, 2020; Kolb & Martin, 2017).

Hypertension is high blood pressure beyond normal levels. It is clinically defined as having a systolic blood pressure measurement of ≥ 140 mmHg or a diastolic blood pressure measurement of ≥ 90 mmHg on two separate days (World Health Organization, 2021c). Hypertension is common in persons with diabetes, high cholesterol, and obesity (Cheng et al., 2022; Tasic & Lovic, 2018).

High cholesterol, or hypercholesterolemia, is a cardiometabolic disorder in which blood cholesterol levels are elevated. Definitions of high cholesterol vary. The World Health Organization defines high cholesterol as total cholesterol ≥ 190 mg/dL (≥ 5.0 mmol/L), whereas U.S. guidelines use ≥ 200 mg/dL (≥ 5.2 mmol/L) as the threshold for high total cholesterol (Expert Panel on Detection & Adults, 2001; Organization, 2013; Stone et al., 2014). There is mixed evidence on the relationship between high cholesterol and cardiovascular disease. While studies have found increased risk of cardiovascular disease among persons with high total cholesterol (Peters et al., 2016), a causal link has been disputed (Ravnskov et al., 2018).

Obesity is a complex disease in which accumulation of excessive body fat impairs health. Obesity is most often classified using body mass index (BMI), though other diagnostic measures exist. The operational definition of obesity is a BMI greater than 30 kg/m^2 (Jensen et al., 2014; North American Association for the Study of Obesity et al., 2000). Obesity is a known risk factor for cardiovascular disease. It is independently associated with cardiovascular disease incidence and mortality (Logue et al., 2011), and is also associated with increased incidence of hypertension, high cholesterol, and diabetes (Drozdz et al., 2021; Kotsis et al., 2018).

1.2.2 Global Prevalence and Impact

Cardiovascular diseases are on the rise globally, leading to substantial loss of life and health as well as considerable healthcare costs. Cardiovascular disease is the world's leading cause of death. In 2019, approximately 18.6 million people died from a cardiovascular disease, compared to 12.1 million in 1990 (Roth et al., 2020). This included 34.4 million years of life lost (YLL) due to premature mortality. Unsurprisingly, the number of persons with cardiovascular disease nearly doubled during this period, from 271 million in 1990 to 523 million in 2019.

Cardiometabolic risk factors relating to cardiovascular disease also take a substantial toll on global health. Hypertension is highly prevalent and is the leading modifiable cardiovascular risk factor leading to premature death. The World Health Organization estimates that 1.28 billion adults between the ages of 30 and 79 have hypertension (World Health Organization, 2023). Approximately 11.3 million deaths were attributed to hypertension in 2021, primarily as a result of heart disease and stroke (Vaduganathan et al., 2022). Likewise, diabetes was recently named a top ten leading cause of death for the first time in 2020 (Pan American Health Organization, 2020). An estimated 462 million people across the world have type 2 diabetes, representing approximately 6.28% of the world's population (Khan et al., 2020).

Diabetes is often syndemic with obesity, meaning that the two cardiometabolic conditions often co-occur and result in exacerbated negative outcomes (Tsai et al., 2017). More than 650 million adults (13%) were thought to be obese in 2016 (World Health Organization, 2021b), and in 2019, approximately 5.02 million deaths and 160 million disability-adjusted life years (DALY) were attributed to high BMI (Roth et al., 2020). There are limited data on the number of people with high cholesterol worldwide. However, a 2008 estimate put global prevalence at 39% (World Health Organization, n.d.).

The burden of cardiovascular disease and related cardiometabolic conditions is not uniformly distributed around the globe. More than 75% of cardiovascular disease deaths take place in low- and middle-income countries, despite their generally younger populations (World Health Organization, 2021a). Furthermore, this burden is increasing at a more rapid rate than in high-income countries (Li et al., 2022). This represents a double threat from current high mortality and projected increases as the populations of low- and middle-income countries age. Studies have also found strong associations between a country's economic status and increasing rates of diabetes,

hypertension, high total cholesterol, and obesity (Balakumar et al., 2016; Mills et al., 2016; Safiri et al., 2022).

It is difficult to overstate the global economic cost of cardiovascular diseases and cardiometabolic risk factors. Data are available primarily from high-income countries, where cardiovascular disease is estimated to account for 12 to 16.5% of healthcare costs annually (Muka et al., 2015). A study examining heart failure in 197 countries estimated an annual cost of $109 billion using 2012 data, including $65 billion in direct costs (Cook et al., 2014). In the United States, the average medical expenditures for persons diagnosed with diabetes are more than twice those of patients without a diabetes diagnosis (American Diabetes Association, 2018). In 2017, Jamaica's Minister of Health said Jamaica would need to spend approximately JMD77 billion (US $510 million) to treat persons with cardiovascular-related diseases and diabetes over the next 15 years (Morris, 2017).

1.2.3 Burden of Cardiometabolic Outcomes in Jamaica and the Caribbean

1.2.3.1 *Cardiovascular Disease and Health*

Available data show a high burden of cardiovascular disease in the Caribbean region. In 2019, an estimated 2.0 million people (age-standardized 137.2 deaths per 100,000 population) died from cardiovascular diseases and their risk factors in the Americas region, encompassing North, Central, South America and the Caribbean and representing 36.4 million years of life lost due to premature death (Pan American Health Organization, 2021). However, the region is highly heterogeneous, with a disproportionate burden on the Caribbean. While a handful of countries such as Argentina, Chile, and Brazil have experienced decreases in cardiovascular disease mortality, Caribbean and Central American countries have largely seen increases (Rivera-Andrade & Luna,

2014). In 2019, Age-standardized mortality rates were highest in Haiti, with an estimated 428.7 deaths per 100,000 population. In Jamaica, deaths from cardiovascular disease were estimated at 155.0 per 100,000 population (Pan American Health Organization, 2021). An analysis of a representative sample of urban Jamaicans from 216 to 2017 found that only 0.51% met the criteria for ideal cardiovascular health based on seven characteristics relating to smoking, BMI, physical activity, healthy diet, blood pressure, blood glucose, and cholesterol (McKenzie et al., 2020). A larger proportion of participants met at least five criteria, though still well short of the majority (22.9%).

1.2.3.2 *Cardiometabolic Outcomes*

Available data show that hypertension, diabetes, obesity, and other cardiovascular disease risk factors are increasingly problematic in the region. Estimates of hypertension are limited by few sources of robust and comparable data in the Caribbean and Latin America (Burroughs Peña et al., 2012). The Pan American Organization reported that age-standardized prevalence of hypertension in adults between 30 and 79 years old was 35.4% (Pan American Health Organization, 2021). A study of a representative sample collected in 2007-2008 found that 25.2% of Jamaicans aged 15 to 74 had hypertension. A 2012 analysis of Jamaicans over age 60 found that 61.4% had hypertension (Mitchell-Fearon et al., 2014). In Trinidad and Tobago, a Caribbean country with comparable cardiovascular disease estimates to Jamaica, self-reported hypertension data put prevalence estimates at 30.2% (Chadee et al., 2013).

Prevalences and projected increases in diabetes and obesity are similarly alarming. The International Diabetes Federation (IDF) estimates that an age-adjusted 11.9% of adults in the North America and Caribbean region have diabetes, compared to 9.8% of adults worldwide (Sun et al., 2022). The IDF names Jamaica among the top five countries in the region for number of people

with diabetes in the 20 to 79 year age group at 231,000 adults (International Diabetes Federation, 2021). In 2007 to 2008, national survey estimates put the prevalence of diabetes at 7.9% and obesity at 25.2% among adults and older adolescents (Ferguson et al., 2011). A 2021 ECLAC report found that 24.0% of Jamaican adults were obese in 2016 compared to 18.9% in Antigua and Barbuda, the Caribbean country with the lowest rates, and 31.6% in the Bahamas, which has the highest rates (Abdulkadri et al., 2021). Moreover, a simulation model based on current trends in Jamaica estimated that diabetes among adults would rise from 12% in 2018 to 20.9% by 2050 (Guariguata et al., 2022). The model also predicted that obesity prevalence would rise from 28.6% in 2018 to 39.2% by 2050.

1.3 Major Risk Factors for Diabetes, Hypertension, High Cholesterol, and Obesity

1.3.1 Cardiometabolic Conditions and the Social Ecological Framework

The prevalence of adverse cardiometabolic outcomes varies by a plethora of intersecting biological, behavioral, and contextual factors, including genetics, age, biological sex, gender, socioeconomic position, lifestyle, social and physical environment, and healthcare access and quality. Research increasingly shows that biological mechanisms for poor cardiometabolic health are influenced by social factors, and that these factors and outcomes are generally inequitable. For example, lower neighborhood SES has been linked to higher risk of adverse cardiac events via stress-associated neurobiological processes in the United States (Tawakol et al., 2019). These findings are just a small sample of the body of evidence that individual factors do fully explain health outcomes, including those related to cardiometabolic health.

A social ecological approach to assessing cardiometabolic risk considers not only individual characteristics but also factors outside of individual influence and the surrounding social and structural context. Researchers involved in the Dallas Heart study proposed a social ecological model for cardiovascular health that includes intrapersonal, interpersonal, neighborhood/community, and public policy levels (Ceasar et al., 2020). This paper will focus on intrapersonal (individual) and neighborhood-level risk factors (see Figure 1).

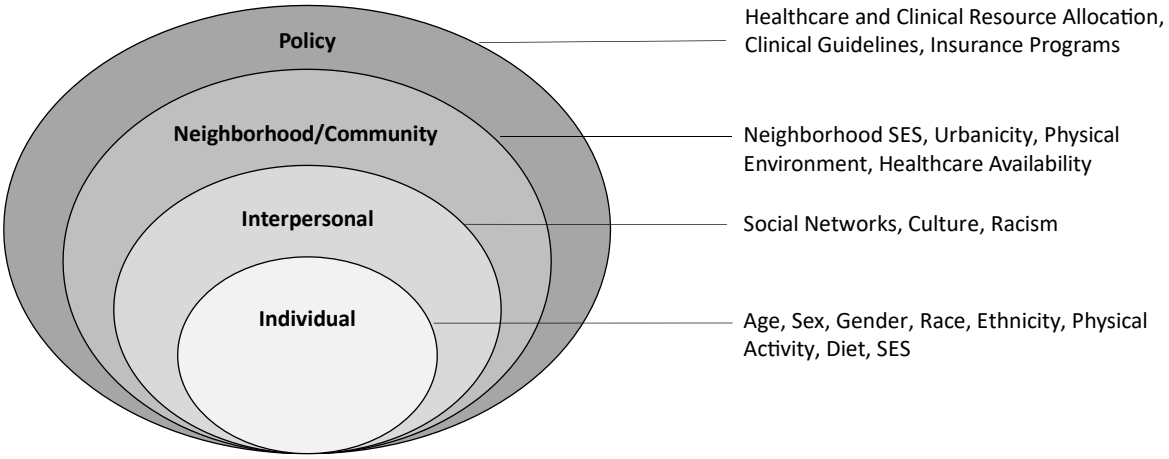

Figure 1 Social Ecological Model of Cardiometabolic Risk

Adapted from Ceasar et al., 2020

1.3.1 Individual Risk Factors for Cardiometabolic Conditions

Individual characteristics, primarily age, sex, and race, are most the frequently reported disparity indicators for cardiometabolic outcomes. Research on health disparities in Caribbean populations is limited, and studies examining how individual SES relates to health outcomes suggest these relationships may be nonlinear. Similar mixed associations have been found in other

low- and middle-income countries, and it has been suggested that economic and epidemiologic transitions in these populations are a contributing factor (Petrovic et al., 2018; Wilkinson, 1994).

1.3.1.1 *Age*

Age is a well-established determinant of cardiometabolic outcomes. Aging is marked by a decline in physiological processes related to cardiovascular and metabolic health (North & Sinclair, 2012; Yazdanyar & Newman, 2009). As a result, risk and prevalence of cardiometabolic and cardiovascular disease generally increase in middle and older age.

Globally, 22% of persons aged 70 and older were estimated to have diabetes in 2019, compared to only 4.4% of persons aged 15 to 49 and 15% of persons aged 50 to 69 (Khan et al., 2020). The risk of type 2 diabetes is also higher in middle-aged adults when compared to younger adults (Centers for Disease Control and Prevention, 2020). However, risk among children and young adults is increasing (Xie et al., 2022). Studies show that diabetes and hypertension prevalence increase with age in Jamaica and the Caribbean (Mitchell-Fearon et al., 2014; Sinclair et al., 2020).

1.3.1.2 *Sex and Gender*

Diabetes, hypertension, high cholesterol, and obesity risk factors and associations differ by sex and gender. Moreover, differences in outcomes between men and women that have been established in high-income countries and other regions of the world do not always apply to Jamaica and the Caribbean.

2019 estimates of hypertension in the Americas region found higher prevalence in men (37.5%) than in women (33.3%) (Pan American Health Organization, 2021). This contrasts with a study of older adults in Jamaica, which found a higher diabetes prevalence among females (72.5%)

than males (49.2%) that persisted even after adjusting for age (Mitchell-Fearon et al., 2014). A longitudinal study of regionally diverse African-origin populations found that 10.0% of Jamaican women and 6.8% of Jamaican men aged 25 to 45 had hypertension at the 2010 to 2011 baseline (Cooper et al., 2015). This is reflected in other Black Caribbean populations. For example, a representative study of adults in Barbados found lower rates of hypertension in men than in women (Howitt et al., 2015). However, the results of the Barbados study were not statistically significant.

Diabetes is more prevalent among women than men in the Caribbean. This contrasts with most regions of the world, where diabetes prevalence is lower or equal for women (Huebschmann et al., 2019). A review of 50 quantitative studies from 2007 to 2013 found that Caribbean women were more likely to have diabetes and obesity compared to Caribbean men (diabetes OR = 1.65, 95% CI 1.43, 1.91) (Sobers-Grannum et al., 2015). An analysis of the 2008 representative sample of Jamaicans aged 15 to 74 found a 9.3% prevalence of diabetes in women compared to 6.4% among men. The reasons for differences between the Caribbean and global trends are not well understood, although a contributing factor may be high rates of obesity and physical inactivity among Caribbean women (Guariguata et al., 2018; Sobers-Grannum et al., 2015).

Women are generally more likely to have obesity than men in the Caribbean, and are also more likely to be physically inactive (Ferguson et al., 2018; Howitt et al., 2015). This is consistent with findings among sub-Saharan African populations in rural and urban settings (Ajayi et al., 2016). A system dynamics model based on 2020 data projected that as obesity prevalence rises in the Caribbean region, the gender disparity will persist but not increase, going from 38.4% among women and 12.5% among men in 2020 to 48.8% among women and 22.2% among men in 2050 (Guariguata et al., 2022).

From a lifecourse perspective, menopause increases cardiometabolic risk in women. Post-menopausal women have higher rates of high total cholesterol, heart disease, and stroke compared to pre-menopausal women (Ambikairajah et al., 2019), and women who experience early menopause have increased type 2 diabetes risk compared to women to enter menopause at a typical age (Yoshida et al., 2021).

While gender is often ignored or used interchangeably with biological sex in studies of cardiovascular disease, there have been public calls for more nuanced analyses that examine the separate and intersectional effects of biological sex and gender as a social construct (O'Neil et al., 2018).

1.3.1.3 *Race, Ethnicity, and Racism*

Race and ethnicity are strongly associated with cardiometabolic outcomes. In 2018, non-Hispanic Black Americans were 60% more likely to be diagnosed with diabetes (Centers for Disease Control and Prevention, 2022) and had a 44% higher prevalence of hypertension when compared to non-Hispanic White Americans (Aggarwal et al., 2021). Several U.S. studies have found that racial and ethnic differences largely result from structural inequities and racism, which take the form of inequitable distribution of resources, stressors, safety, healthcare access and quality, and socioeconomic opportunities that result in poorer health outcomes for communities of color (Javed et al., 2022; Williams & Mohammed, 2013).

There are also differences between Black Caribbean populations and African-descent populations in other geographic regions. A scoping review of studies published between 1972 and 2013 found higher prevalence of diabetes among Caribbean Black adults compared to Caucasians and West African Black adults (Bennett et al., 2015). However, Black Jamaicans had a lower prevalence of hypertension and diabetes compared to Black Americans when comparing

participants of the U.S. Jackson Heart Study and the Jamaica Spanish Town Cohort Study (Bidulescu et al., 2017). In this study, disparities in hypertension and diabetes associated with education level persisted among Black Americans but not Black Jamaicans when analyses were adjusted for age, sex, and BMI.

1.3.1.4 *Individual SES*

Relationships between SES and cardiometabolic outcomes vary depending on the specific disease, the SES indicator selected, geographic region, and individual and neighborhood characteristics. In high-income countries, adverse cardiometabolic conditions are generally more prevalent among persons with low SES (Rosengren et al., 2019). However, this relationship is more complex in less wealthy countries. A prospective cohort study of more than 160,000 persons from countries spanning all income classifications found that, in low- and middle-income countries, people with lower levels of education had better risk profiles than their more educated compatriots but higher cardiovascular disease incidence and mortality (Rosengren et al., 2019). Researchers concluded that poorer healthcare among people with lower educational attainment played a role. Diabetes prevalence was higher among persons with lower income and educational attainment in a review of studies of Caribbean Black populations in the United Kingdom, Jamaica, and Trinidad and Tobago (Bennett et al., 2015). However, SES was considered in only five of the 43 studies reviewed by the authors.

Relationships between SES and cardiometabolic outcomes often differ by sex in Afro-Caribbean populations. A cross-sectional study of young Jamaican adults found lower odds of hypertension for lower SES among women but not men (Ferguson et al., 2018), where SES was determined by number of household possessions. In a nationally representative sample of African American and Black adults collected from 2001 to 2003, obesity was positively associated with

family income among Afro-Caribbean men but not women, though receipt of public assistance was associated with greater obesity in both men and women (Barrington & Powell-Wiley, 2022). This is consistent with findings of a strong positive association of income with obesity in Jamaican men in an analysis of an older population-based survey (Mendez et al., 2004). Among women, obesity levels were high at all income levels and the effect of income was more moderate. Analyses of Jamaican adults evaluated between 1993 and 2001 also found that high income was associated with greater odds of metabolic syndrome among men but not women after adjusting for age group (Ferguson et al., 2010).

There is also evidence that cholesterol prevalence may be higher in persons of higher socioeconomic status in the Latin America and Caribbean region. A study of Brazilian adults aged 25 to 64 years old found that a composite score of socioeconomic status taking into account family income, education level, and the number of consumer goods in the home found that men and women with higher SES had higher levels of total cholesterol, with no significant changes when controlling for individual age, BMI, and physical activity (Espírito Santo et al., 2019).

1.3.1.5 *Individual Lifestyle Factors*

Diet, physical activity level, smoking status, and alcohol use influence cardiometabolic risk. American College of Cardiology and American Heart Association guidelines emphasize a healthy diet, low sodium intake, adequate physical activity, moderate alcohol use, and tobacco-free lifestyle to prevent cardiovascular disease, diabetes, and obesity (Arnett et al., 2019). An analysis of the 1990 to 2021 Global Burden of Disease Study found that diet, smoking, high alcohol use, and low physical activity were among the top modifiable risk factors contributing to cardiovascular disease death and disability (Vaduganathan et al., 2022). A systematic review of longitudinal studies published between 2012 and 2019 found that physical activity was associated

with lower risk of new-onset obesity, diabetes, and coronary heart disease, but not hypertension in adults (Cleven et al., 2020).

In the Caribbean, physical activity and diet have been linked to obesity and diabetes in women, and smoking has been identified as a cardiometabolic risk factor in men (Ferguson et al., 2018; Howitt et al., 2015). An unpublished phase 1 analysis of the Jamaica salt consumption, Knowledge, Attitudes, and Practices (Salt-KAP) study found that 67% of Jamaicans consume more than the recommended 2 grams of daily sodium intake (Ferguson et al., 2022). On average, daily intake was nearly twice the recommended amount at 3.6 grams.

1.3.1.6 *Clustering and Comorbidity of Cardiometabolic Outcomes*

There is evidence that individual cardiometabolic risk factors often occur in clusters and may interact with each other. For example, adults with diabetes are significantly more likely to have hypertension, high cholesterol, and obesity than persons without diabetes (American Diabetes Association, 2014; Matheus et al., 2013; Strain & Paldánius, 2018). Obesity increases the risk of diabetes and hypertension in developing countries (Gallardo-Rincón et al., 2021). In Jamaica, high cholesterol is highly prevalent among primary care patients who have hypertension and diabetes (Harris et al., 2017). Impaired glucose tolerance, hypertension, high cholesterol, and obesity often present together in a condition recognized as the metabolic syndrome (Bozkurt et al., 2016).

1.3.2 Neighborhood-Level Risk Factors for Cardiometabolic Outcomes

Neighborhood environments are significant and modifiable determinants of cardiometabolic risk factors and outcomes. Analyses have found that both objective neighborhood characteristics and subjective neighborhood perceptions are associated with differences in

diabetes, hypertension, obesity, high cholesterol, and ideal cardiovascular health. While much research has been published in recent decades about neighborhood disparities and health outcomes, this remains an area of nascent exploration in Jamaica and the Caribbean.

1.3.2.1 *Urbanicity*

In most regions of the world, urban areas have higher burdens of diabetes, obesity, and metabolic dysfunction when compared to rural areas. According to the International Diabetes Federation Atlas, of the approximately 463 million people in the world with diabetes, 67% live in urban areas (Saeedi et al., 2019). A cross-sectional series study of 13 Latin American and Caribbean countries, including Haiti and the Dominican Republic, found a consistently higher burden of obesity among urban residents in most countries (Jiwani et al., 2019). Differences in rural and urban outcomes are likely due to environmental and lifestyle variations between these settings. Residents of urban environments are exposed to greater neighborhood stressors (Mahasin S. Mujahid et al., 2011), more refined and energy-dense foods (Rosenheck, 2008), and more sedentary lifestyles (Lee et al., 2009) when compared to those who live in less urban areas.

Experiences of migrants from rural to urban communities indicate that difficulty adapting to the urban setting may worsen cardiometabolic outcomes. The PERU MIGRANT study found that rural-to-urban immigrants who were older than 12 at migration had a higher probability of developing diabetes and metabolic syndrome in later life when compared to people who migrated at a younger age (Miranda et al., 2012). Ostensibly, people migrating at an earlier age have comparatively lower risk because they are better able to adjust to the urban environment and lifestyle.

1.3.2.2 *Neighborhood SES*

Studies in the United States have provided evidence that neighborhood SES influences cardiometabolic outcomes. Chronic neighborhood stressors (physical disorder and violence) contributed to racial and ethnic differences in hypertension prevalence in a diverse multi-ethnic study (M. S. Mujahid et al., 2011). Similarly, a cohort study of low-income Black and White adults in the southeastern United States found that living in neighborhoods with fewer resources worsened heart failure risk above and beyond the effect of individual risk factors, including individual SES (Akwo et al., 2018). This was consistent with previous findings that neighborhood deprivation was associated with a higher prevalence of obesity and elevated blood glucose in a racially diverse multi-county California study (Laraia et al., 2012). This association remained significant after adjusting for individual income and education.

Studies of Jamaican and Caribbean populations are more limited in comparison to the United States, and many are based on older data. Moreover, relationships between neighborhood socioeconomic status and cardiovascular-related outcomes often differ for Jamaican men and women, though the reasons are not clear. A study of a 2016-2017 representative sample in urban Jamaica found that men residing in low-SES communities based on median land value had lower odds of ideal cardiovascular health compared to men living in high-SES communities. In contrast, women in low-SES communities had higher odds of ideal cardiovascular health (McKenzie et al., 2020).

Analysis of a 2008 sample found that poorer neighborhood infrastructure was associated with lower levels of physical activity in Jamaican men and higher levels of overweight and obesity in women (Cunningham-Myrie et al., 2015). Older data also show evidence of lower physical activity and higher biological cumulative risk among Jamaican women who live in neighborhoods

with higher perceived neighborhood disorder (Cunningham-Myrie et al., 2018). A pooled analysis of 2005 to 2008 data on Jamaican youth found that SES was inversely associated with systolic blood pressure among young men, based on composite scores incorporating poverty, unemployment, dependency ratio, population density, house size, and tertiary education (Ferguson et al., 2020).

1.4 Gaps in Knowledge About Neighborhood Risk Factors and Cardiometabolic Outcomes in Jamaica

Few studies have examined the relationship between neighborhood SES and cardiometabolic outcomes in Afro-Caribbean populations. In the context of Jamaica, much of the available research utilizes older data, including those obtained from the 2007-2008 Jamaica Health and Lifestyle Survey (Cunningham-Myrie et al., 2018; Ferguson et al., 2020; Ferguson et al., 2010), or focuses on other neighborhood characteristics such as physical environment (Cunningham-Myrie et al., 2015). An analysis of more recent data has been published exploring the relationship between neighborhood property value and ideal cardiovascular health, but it did not examine adverse outcomes such as diabetes, hypertension, high cholesterol, and obesity (McKenzie et al., 2020). The present study seeks to address this gap and add to the discourse by not only examining the relationship between neighborhood SES measured by median property sales price and cardiometabolic outcomes, but also taking into account the effects of other neighborhood SES characteristics such as average employment rates, education levels, and dependency ratios.

1.5 Public Health Significance

Diabetes, hypertension, high cholesterol, and obesity are highly prevalent in Jamaica and the Caribbean, leading to increased cardiovascular risk. Diabetes, hypertension, high cholesterol, and obesity are highly prevalent in Jamaica and the Caribbean, leading to increased cardiovascular disease risk. In Jamaica, approximately 155.0 per 100,000 population die as a result of cardiovascular disease each year, compared to 128.0 per 100,000 in the United States when standardized for age (Pan American Health Organization, 2021). In a nationally representative survey of Jamaicans aged 15 to 74 conducted in 2007 to 2008, 25.2% had hypertension and obesity, 11.7% had high cholesterol, and 7.9% had diabetes (Ferguson et al., 2011). These numbers have been rising as Jamaica becomes increasingly urbanized and sedentary and transitions to more calorie-dense diets. One study projects that obesity and diabetes will rise from 28.6% and 12.0% in 2018 to 39.2% and 20.9% in 2050 (Guariguata et al., 2022).

Despite the rising burden of adverse cardiometabolic outcomes, their relationship to neighborhood SES is not well understood. In contrast to what is typically observed in the United States and other high-income countries, low SES is not always associated with worse cardiometabolic outcomes among Jamaicans and other Afro-Caribbean populations (Akwo et al., 2018; Laraia et al., 2012; Mahasin S. Mujahid et al., 2011). In addition, the interactions between sex or gender and cardiometabolic health observed in other countries sometimes differ from those observed in Jamaica (Barrington & Powell-Wiley, 2022; Ferguson et al., 2020; Ferguson et al., 2010; Mendez et al., 2003). A deeper exploration of these patterns is a necessary step in understanding the determinants of cardiometabolic outcomes and cardiovascular risk, and for proposing effective interventions in Jamaica and the surrounding region.

2.0 Objective

The objective of this study is to explore associations of neighborhood SES, as measured by property sales data, with adverse cardiometabolic outcomes (diabetes, hypertension, high cholesterol, and obesity) in the context of urban Jamaica.

3.0 Methods

3.1 Data Collection and Sample

3.1.1 Survey Data Collection

We conducted a cross-sectional analysis using demographic, health, and anthropomorphic data collected in a phase two Lown ancillary study to the Jamaica Health and Lifestyle Survey 2016 to 2017 (JHLS-III). Details of JHLS-III and the ancillary study design have been previously published (Ferguson et al., 2017; McKenzie et al., 2020). Trained interviewers administered questionnaires to collect information on demographic characteristics, medical history, cigarette smoking, physical activity, and dietary practices. Anthropomorphic measurements, blood pressure, fasting glucose, and total cholesterol were collected using standardized protocols used in previous JHLS surveys (Wilks R et al., 2008; Wilks et al., 2007) and described in published research (McKenzie et al., 2020).

Phase two of the Lown ancillary study revisited all available JHLS-III participants (n = 1,130) aged 15 and older from the urban areas of four parishes constituting Jamaica's Southeast Health Region (Kingston, St. Andrew, St. Catherine, and St. Thomas) to collect additional data and readminister questionnaires and measurements for participants seen more than three months after the initial survey. Urban areas were identified with the classification used by the Statistical Institute of Jamaica (https://statinja.gov.jm/Methodology.aspx#concepts). Phase two participant addresses were combined with geo-informatics systems data and other government sources to group participants into enumeration districts (ED). EDs are the smallest geographic unit used in

Jamaica's national household census. Each ED comprises approximately 150 dwellings in urban areas (Statistical Insititute of Jamaica, 2012). These data were also used to group participants into communities with geographic bounds defined by the Social Development Commission (SDC) (https://sdc.gov.jm/about-us), the government agency responsible for the organization and development of Jamaica's 775 communities. The SDC defines "community" as a geographic area that groups people taking into account "common ownership of resources or sharing of social, economic and cultural facilities" (Social Development Commission, 2015). Residents within an SDC community interact with each other and believe they have common objectives, interests, and needs. In the present study, a "neighborhood" is synonymous with an SDC community.

Participants provided written informed consent and the study was approved by the University of the West Indies (UWI) Mona Campus Research Ethics Committee (MCREC) (ECP89 16/17). All data were deidentified by UWI before they were accessed by researchers from the University of Pittsburgh.

3.1.2 Obtaining Property Sales Data

Property value is an emerging measure of socioeconomic status that is highly correlated with wealth and strongly predictive of health outcomes (Connolly et al., 2009; Leonard et al., 2016; Rodrigues et al., 2021). Though it is a relatively novel measure, property value has proven meaningful in studies of neighborhood SES and cardiometabolic outcomes (Coffee et al., 2013; Drewnowski et al., 2015), including in a recent study of ideal cardiovascular health in Jamaica (McKenzie et al., 2020). Conceptually, property values include the value of the land and household improvements added to the land (Rodrigues et al., 2021). For this reason, property sales prices were chosen as the primary neighborhood SES measure rather than unimproved property values.

Property sales data were obtained from the National Land Agency (NLA) http://www.nla.gov.jm/content/background), which is responsible for property valuation in Jamaica. These data were downloaded using the NLA's JAMPROP tool (https://jampropsales.nla.gov.jm/about.aspx) for the entire island of Jamaica, then merged with unimproved property data obtained for the Lown ancillary to match each property with its corresponding ED number. The process for obtaining unimproved property data for the Lown ancillary study and overlaying EDs via shapefile has been previously published (McKenzie et al., 2020). The merged data file was then reduced to include only properties in the EDs represented in the phase two ancillary study.

The final property data file included all properties within the EDs represented by the phase two ancillary study whose sale was registered between 2003 and 2021. While the ancillary study included 44 EDs, the final data file for the present study included only 43 EDs as there was no sales data for properties in ED 101063, which represents an area of Downtown Kingston where eight participants in the phase two ancillary study resided. Data for the 43 EDs included 1,083 parcels of land spanning 36 neighborhoods in four parishes.

3.1.3 Obtaining Additional Neighborhood Characteristic Data

Additional socioeconomic characteristics for each community were obtained from SDC community profiles (https://sdc.gov.jm/documents). Variables included dependency ratio and proportion of community households receiving state assistance, as well as employment and educational attainment of household heads. SDC profiles are compiled by SDC Community Development Officers using data collected by trained community members using SDC questionnaires and tools. Profiles used in the present study were published between 2004 and 2017.

3.1.4 Study Sample

Of 1,130 unique participant records in the dataset, 281 had no demographic and outcome data attached and were removed. T-tests revealed no statistically significant differences in average property sales price when comparing records with demographic data and records for which demographic data was missing. An additional 16 observations were excluded because there was no data available with which to identify their community. $\chi 2$ tests showed no statistically significant differences in outcomes or individual characteristics when comparing these 16 observations with the remaining dataset. The final analytical sample consisted of 833 participants (577 women and 282 men).

3.2 Measures

3.2.1 Neighborhood SES Exposure Variable

We selected median property sales price as our primary exposure variable and the remaining neighborhood SES variables as covariates. Sales prices were first converted to 2019 equivalent Jamaican dollars (JMD) to account for inflation, which ranged from 2.4% to 22.0% from 2003 to 2022, which is the time period used for property sales in this study (World Bank, 2023). For properties with multiple sales transactions during the study period, only the most recent transaction was retained. Descriptive analyses explored the land use types for the various properties and the proportion of residential versus commercial properties in the dataset (not reported). Property sales prices were ranked and the median price was calculated for each parish,

ED, and neighborhood. Median property sales price at the neighborhood level was coded as the summative variable representing neighborhood SES. Neighborhoods were ranked and categorized into low SES (JMD 9,284 to 2.22M), mid SES (JMD 2.60M to 7.89M), and high SES (JMD 8.30M 3.85B) based on median property sales price.

3.2.2 Covariates

The remaining neighborhood variables were selected as neighborhood-level covariates. Dependency ratio was defined as the number of dependents aged 0 to 14 and older than 65 divided by the total neighborhood population aged 15 to 64, expressed as a percentage. A high dependency ratio indicates a high economic burden on the working-age population (Jonathan Vespa et al., 2020). Educational attainment at the neighborhood level was defined by the percentage of household heads in the neighborhood with at least a secondary level education. Employment was defined by the percentage of household heads employed. State assistance was defined by the percentage of households receiving state assistance in the neighborhood. For each variable, neighborhoods were ranked and classified into low, mid, and high SES categories and reported in Table 1.

Individual characteristics were also included as covariates and potential confounders. Age was categorized into four groups: < 25 years, 25 to 44, 45 to 64, and ≥ 65. Sex was classified as female or male. Individual educational attainment was classified as “less than high school” for participants educated up to grade 8, “high school” for participants with some secondary level education (grades 9-13), and “more than high school” for participants educated beyond the secondary level. The remaining covariates were coded as binary variables. Participants who reported never smoking or having quit for longer than 12 months were classified as non-smokers.

Participants engaging in adequate physical activity were defined as those who were moderately active for at least 150 minutes each week or vigorously active for at least 75 minutes each week (World Health Organization, 2020b). Weekly physical activity duration was calculated by multiplying each participant's reported days with moderate or vigorous activity each week by their reported number of moderately or vigorously active minutes for each day. Healthy diet was defined using American Heart Association guidelines which set recommendations for intake of fruit, vegetable, whole grain fiber, sodium, and sugar-sweetened beverages (Lloyd-Jones et al., 2010). Healthy diet was coded for participants who met three or more of the following criteria based on self-reported dietary behavior: (1) low-salt diet, defined as no added salt at the table and "rarely" or "never" eating processed foods; (2) low sugar-sweetened beverage (SSB) consumption, defined as consuming less than SSBs each week; (3) adequate fruit and vegetable consumption, defined as eating fruits or vegetables three or more times per day; and (4) adequate fish consumption, defined as eating fish two or more times each week. Dietary fiber was not included in our definition as the Lown ancillary study did not obtain data on whole grain intake.

3.2.3 Cardiometabolic Outcome Variables

Guidelines for categorizing cardiometabolic outcomes are based on the Jamaican context and clinical standards at the time of data collection. Diabetes was defined as fasting glucose ≥ 7.0 mmol/L or a self-reported physician diagnosis of diabetes (Blonde et al., 2022; World Health Organization, 2006). Hypertension was defined as an average systolic blood pressure ≥ 140 mmHg or average diastolic blood pressure ≥ 90 mmHg for the second and third of three consecutive blood pressure readings, or a self-reported physician diagnosis of hypertension (World Health Organization, 2021c). High cholesterol was defined as total cholesterol ≥ 5.2 mmol/L or a self-

reported physician diagnosis of high cholesterol (Stone et al., 2014). Obesity was defined as BMI ≥ 30 kg/m^2 (Jensen et al., 2014).

3.3 Statistical Analysis

3.3.1 Descriptive Statistics and Regression

Data analyses were performed using Stata V.17.0 software. Crude and sex-specific descriptive statistics were produced for outcomes, exposures, and covariates. An a priori decision was made to stratify by sex because prior work in Jamaica has shown cardiometabolic outcomes and their relationship to exposures typically defer by sex. Differences in characteristics across sex and neighborhood SES categories were compared using χ^2 tests. The prevalence of each outcome was estimated within and across sex and neighborhood SES categories. Weighted Poisson regression models were used to estimate prevalence ratios (PR) for each outcome within and across sexes using three models. Weights accounted for the survey sampling design and the age and sex distribution of the Jamaican population. Model 1 estimated crude PRs (outcome and main exposure only). Model 2 adjusted for individual risk factors (sex, age group, education level, smoking, diet, and physical activity). Model 3 adjusted for individual risk factors as well as neighborhood covariates (education level, dependency ratio, employment, and state assistance). Weighted Poisson and negative binomial are the preferred forms of regression for estimating prevalence ratios (Chen et al., 2018; Petersen & Deddens, 2008). Equality of mean and variance was assessed for all models and variance inflation factor was assessed for adjusted models to satisfy regression assumptions. A listwise deletion approach was applied to missing data.

4.0 Results

4.1 Sample Characteristics

Summary statistics for participant characteristics are shown in Table 1. Most participants were in the ≥45 to 64 age group (34.9%) and had at least a high school education (77.7%). Among cardiometabolic outcomes, hypertension was the most prevalent in the sample (50.5%), followed by obesity (37.0%). In comparison, 30.1% of participants had high cholesterol, and 16.9% had diabetes, as indicated by measured high blood glucose or a self-reported doctor diagnosis.

Men were significantly more likely to be adequately physically active (52.4% vs. 42.0%, p = 0.003) and current smokers (29.7% vs. 10.8%, p <0.001). Significantly more women had hypertension (53.0% vs. 45.6%, p = 0.047), high cholesterol (34.3% vs. 21.7%, p <0.001), and obesity (45.7% vs. 19.4%, p <0.001). There was evidence of marginally significant sex differences in the distribution of neighborhood SES as determined by median property sales price (p = 0.052) and average proportion of household heads employed (p = 0.057).

Table 1 Sociodemographic, cardiometabolic, and individual and neighborhood characteristics of the sample stratified by sex

	Women (n=557)	**Men (n=282)**	**Total (n=833)**	**P-value[1]**
	n (%)	n (%)	n (%)	
Age group				0.191
Age <25	68 (12.2)	48 (17.4)	116 (3.9)	
Age 25 to 44	171 (30.7)	79 (28.6)	250 (30.0)	
Age 45 to 64	202 (36.3)	89 (32.2)	291 (34.9)	
Age ≥65	116 (20.8)	60 (21.7)	176 (21.1)	

	Women (n=557)	Men (n=282)	Total (n=833)	P-value[1]
Educational attainment				0.921
Less than high school	124 (22.6)	59 (21.4)	183 (22.2)	
High school	285 (52.0)	144 (52.4)	429 (52.1)	
More than high school	139 (25.4)	72 (26.2)	211 (25.6)	
Adequate physical activity (≥150 min moderate or 75 min vigorous activity / week)	232 (42.0)	144 (52.4)	384 (45.7)	0.003*
Healthy diet (≥3 of 4 dietary factors)[2]	133 (23.9)	60 (21.7)	193 (23.2)	0.491
Current smoker	60 (10.8)	82 (29.7)	142 (17.0)	<0.001*
Measured or self-reported doctor diagnosis of diabetes	101 (18.2)	40 (14.5)	1141 (16.9)	0.184
Measured or self-reported doctor diagnosis of hypertension	295 (53.0)	126 (45.6)	421 (50.5)	0.047*
Measured or self-reported doctor diagnosis of high cholesterol	191 (34.3)	60 (21.7)	255 (30.1)	<0.001*
Obesity (BMI ≥30)	245 (45.7)	51 (19.4)	296 (37.0)	<0.001*
Neighborhood SES (Median property sales price)[3]				
Low (JMD 9,284 to 2.22M)	198 (35.5)	95 (34.4)	293 (35.2)	0.052**
Mid (JMD 2.60M to 7.89M)	194 (34.8)	78 (28.3)	272 (32.6)	
High (JMD 8.30M 3.85B)	165 (29.6)	103 (37.3)	268 (32.2)	
Household heads with ≥ secondary education				
Low (17.9 to 42%)	165 (33.6)	95 (39.4)	260 (35.5)	0.298
Mid (42.3 to 54.2%)	160 (32.6)	73 (30.3)	233 (31.8)	
High (54.5 to 62.3%)	166 (33.8)	73 (30.3)	239 (32.6)	
Dependency ratio[4]				
Low (36.8 to 48.0%)	157 (31.7)	92 (38.2)	249 (33.8)	0.196
Mid (48.8 to 57.0%)	171 (34.5)	79 (32.8)	250 (34.0)	
High (58.0 to 78.3%)	167 (33.7)	70 (29.0)	237 (32.2)	
Household heads employed				
Low (36.4 to 58.8%)	157 (33.8)	98 (42.6)	255 (36.7)	0.057**
Mid (59.0 to 70.0%)	194 (41.7)	78 (33.9)	272 (39.1)	
High (70.5 to 75.0%)	114 (24.5)	54 (23.5)	168 (24.17)	
Households receiving state assistance				
Low (3.6 to 8.6%)	207 (46.6)	81 (37.7)	288 (43.7)	0.073**

	Women (n=557)	Men (n=282)	Total (n=833)	P-value[1]
Mid (9.0 to 14.8%)	117 (26.3)	61 (28.4)	178 (27.0)	
High (16.0 to 24.3%)	120 (27.0)	73 (33.9)	193 (29.3)	

*Statistically significant differences between women and men ($p < 0.05$)
**Marginally significant differences between women and men ($0.075 < p < 0.05$)
1. P-values were calculated using χ^2 tests.
2. Participants were classified as having a healthy diet if they ≥3 of the following dietary characteristics: (1) low-salt diet, defined as no added salt at the table and rarely or never eats processed foods; (2) low sugar-sweetened beverage (SSB) consumption, defined as SSB intake less than twice per week; (3) adequate fruit and vegetable consumption, defined as intake of fruits or vegetables ≥3 times per day; and (4) adequate fish consumption, defined as eating fish ≥2 times per week.
3. Median property sales prices at the neighborhood level, with neighborhoods categorized as low, mid, and high. Reported in Jamaican dollars (JMD).
4. Dependency ratio is the number of dependents age 0 to 14 and over the age of 65, compared with the total population age 15 to 64, expressed as a percentage.

4.2 Neighborhood SES Characteristics

Neighborhoods in the highest SES tier had an average median property sales price of JMD 20.07 (n = 13, SD = 10.07), compared to 1.90 (n = 12, SD = 1.10) for neighborhoods in the lowest tier and 5.97 (n = 11, SD = 1.32) in the middle tier. Figure 1 shows the distribution of neighborhood median property sales prices for each neighborhood SES tier.

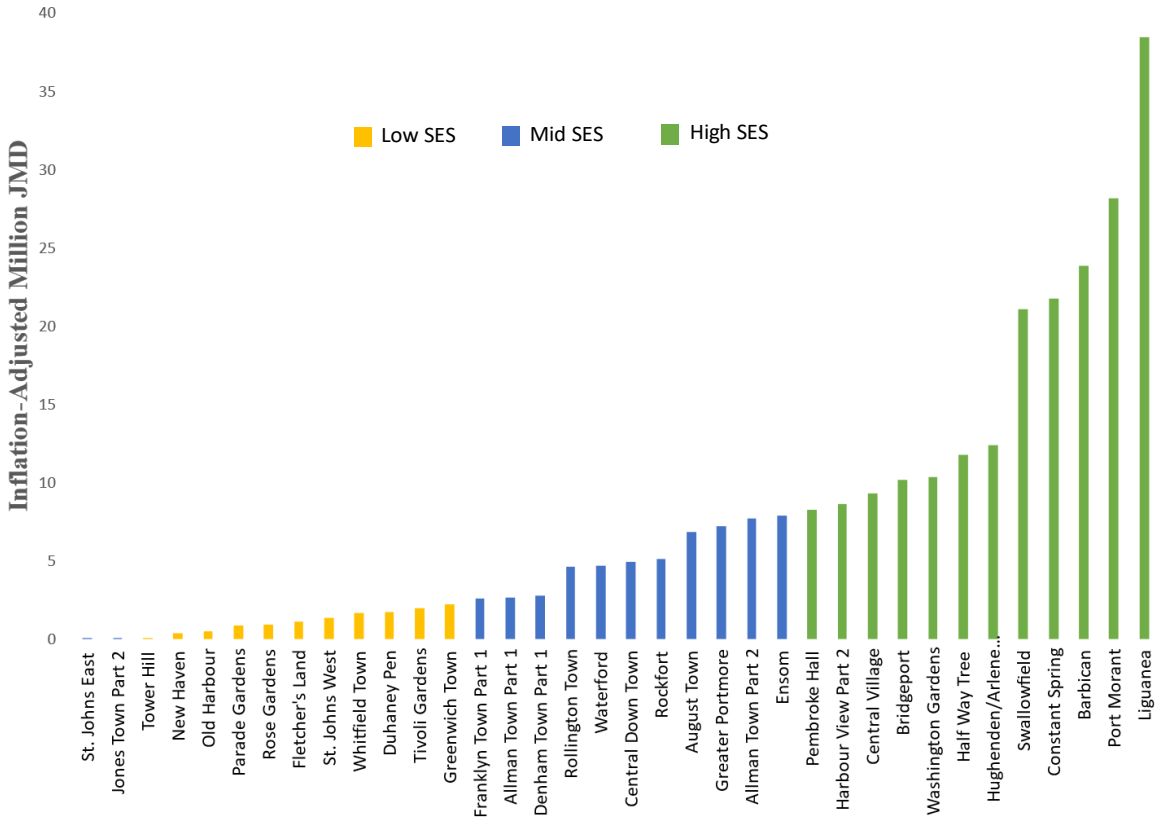

Figure 2 Median Property Sales Price and SES Categories Across Neighborhoods

Summary statistics for participants' cardiometabolic outcomes stratified by neighborhood SES (both primary exposure and covariates) are provided in Appendix Table 1 through 5. There was a significant crude association between high cholesterol and the primary SES variable, median property sales price ($p < 0.001$). In pairwise analyses, more participants living in high SES neighborhoods had high cholesterol (39.5%) versus those living in low SES (22.9%) or mid SES (28.7%) neighborhoods (both $p < 0.001$). When stratified by sex, associations remained significant and consistent. More women and men in high SES neighborhoods had high cholesterol than those in low SES neighborhoods (women: 43.0% vs. 28.3%, $p = 0.003$; men: 34.0% vs. 11.6%, p

<0.001). Neighborhood SES was not significantly associated with diabetes, hypertension, or obesity.

4.3 Neighborhood-Level Covariates

There was also a significant crude association between high cholesterol and median dependency ratio (p = 0.014). The frequency of high cholesterol was greater among participants living in neighborhoods with low economic burdens, as indicated by low dependency ratios, versus those in neighborhoods with high dependency ratios (36.5% vs. 24.5%, p = 0.004). Marginally more women and significantly more men in neighborhoods with low dependency ratios had high cholesterol when compared to their counterparts in neighborhoods with mid-levels of dependency ratio (women: 43.0% vs. 33.0%, p = 0.050; men: 34.0% vs. 17.9%, p <0.016).

There was also a significant crude association between diabetes and household head employment (p = 0.026). However, in contrast to high cholesterol, the frequency of diabetes was lower among participants living in neighborhoods with high levels of employment (10.8% vs. 20.8%, p = 0.007) and among those living in neighborhoods with high vs. mid-levels of employment (10.8 vs. 18.4%, p = 0.033). The association between dependency ratio and diabetes was not significant when stratified by sex. In addition, there were no significant crude or sex-stratified associations between household head education level or household state assistance for any of the cardiometabolic outcomes.

4.4 Individual-Level Covariates

The distributions of individual risk factors in relationship to SES as determined by median property price are shown in supplemental Appendix Table 6. Among participants living in neighborhoods with higher property prices, more were 65 or older (28.0% vs. 18.4%, $p = 0.039$) and had attained more than a high school education (43.4% vs. 15.3%, $p < 0.001$) in comparison to participants on low-SES neighborhoods. Age differences remained statistically significant for women but not men in stratified distributions. Education differences remained statistically significant for men and women in stratified analyses. More participants in the highest property price tier also had healthy diets when compared to those in the lowest property price tier (34.7% vs. 20.5%, $p < 0.001$), though participants in the middle tier had marginally less healthy diets than those in the lowest tier (14.7% vs. 20.5%, $p = 0.072$). The difference in diet between those in low and high SES neighborhoods was significant only for women and not men in stratified analyses. Physical activity also appeared to be worse for participants in higher SES neighborhoods. Fewer participants in neighborhoods with high property prices engaged in adequate physical activity when compared to those in neighborhoods with low property prices (42.0% vs. 53.1%, $p = 0.009$). Participants in middle-tier neighborhoods similarly had lower levels of physical activity (41.1% vs. 53.1%, $p = 0.005$). Stratified analyses showed these differences were significant in women only, with no significant associations among men. Current smoking was generally more common among participants in neighborhoods with low property prices compared to those with high prices (21.8% vs. 9.33, $p < 0.001$), though there was virtually no difference in comparison to those in the middle price tier (21.8% vs. 19.5, $p = 0.490$). This difference was significant in men but not women in stratified comparisons.

4.5 Missingness in the Data

Analyses of the final dataset showed missingness was less than 5% among variables except for neighborhood SES covariates, namely household heads with at least secondary education (12.12%), dependency ratio (11.64%), household heads employed (16.57%), households receiving state assistance (20.89%). $\chi 2$ tests revealed no statistically significant differences in outcomes or exposures when comparing observations for whom state assistance was missing with those for whom it was available.

4.6 Regression Results

Tables 2 through 4 display unstratified and sex-stratified prevalence ratios for each cardiometabolic outcome with the main neighborhood SES measure, median property sales price. High cholesterol and obesity showed the strongest unstratified associations with property prices. Residing in the highest SES category was associated with greater prevalence of high cholesterol when compared with the lowest SES category (PR = 2.53, $p < 0.001$), even after adjusting for individual risk factors (PR = 2.20, $p<0.001$) and other neighborhood SES characteristics beyond property prices (PR = 2.46, $p < 0.001$). When stratified by sex, men in the highest SES category remained more likely to have high cholesterol without adjusting for other factors (PR = 3.83, $p = 0.005$) and after adjusting for individual characteristics (PR = 3.97, $p = 0.009$) and other neighborhood factors (PR = 4.70, $p = 0.005$). Women residing in the highest SES category had greater high cholesterol prevalence only when crudely associated (PR = 2.04, $p = 0.003$). These

associations were no longer significant in models that included the effects of individual- and neighborhood-level covariates.

Obesity had a crude marginal association with property price (i.e., not adjusted for any covariates) in the model for the middle (PR = 1.26, p = 0.066) and highest (PR = 1.26, p = 0.051) SES categories. This association became significant for the middle SES tier (PR = 1.35, p = 0.006) and remained marginal for the highest SES tier (PR = 1.26, p = 0.070) when adjusted for individual risk factors. After adjusting for other neighborhood characteristics, both the middle and highest SES tiers had increased obesity prevalence when compared to the lowest SES tier (middle PR = 1.46, p <0.001); highest: PR = 1.60, p <0.001). These relationships remained somewhat similar in models assessing women only. Prevalence was higher among women in the middle SES tier after adjusting for individual risk factors (PR = 0.017, p = 0.003) and marginally higher for this SES category when also taking into account neighborhood characteristics (PR =1.30, 0.053). Women in the highest SES category also experienced higher levels of obesity when controlling for individual and neighborhood covariates (PR = 1.32, p = 0.015), but not when considering crude associations or individual covariates only. For men in contrast to women, obesity prevalence appeared higher among high SES residents in crude analyses (PR = 2.13, p = 0.018) but did not remain significantly associated when differences in individual and neighborhood characteristics were considered.

Hypertension was also significantly associated with median property price in analyses unstratified by sex. Prevalence was higher for the high SES category (PR = 1.23, p = 0.019) when compared to low SES. This association disappeared when adjusting for individual risk factors only, but reemerged when neighborhood characteristics were added to the model (PR = 1.33, p = 0.044). However, when stratified by sex, no significant associations were observed for women. Among

men, the association between median property price and increased hypertension was no longer statistically significant for the highest SES tier (PR = 1.69, p = 0.143) but was significant for the middle tier when compared with the lowest SES tier (PR = 2.02, p = 0.024).

There were also some significant associations between diabetes and neighborhood property prices for the middle SES categories. In models unstratified by sex, there appeared to be a higher diabetes prevalence among middle-SES persons versus low-SES persons (PR = 2.07, p = 0.012) that remained significant when individual risk factors were added (PR = 2.28, p = 0.002), but was no longer significant when neighborhood characteristics beyond property prices were considered. These patterns remained consistent among men, who had higher diabetes prevalence for the middle SES tier only in models considering crude associations (PR = 2.70, p = 0.043) and individual risk factor adjustments (PR = 2.28, p = 0.042). There were no significant associations between diabetes and property prices among women, although there was a marginally significant increase in prevalence for the middle tier when individual risk factor characteristics were accounted for (PR = 1.75, p = 0.051).

Table 2 Prevalence ratios for association between neighborhood SES and cardiometabolic outcomes (men and women)

	Diabetes		Hypertension		High Cholesterol		Obesity	
	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value
Crude								
Low (ref)	–		–		–		–	
Mid	2.07 (1.18, 3.62)	0.012	1.05 (0.82, 1.33)	0.696	1.36 (0.93, 1.97)	0.107	1.26 (0.98, 1.62)	0.066
High	1.43 (0.70, 2.93)	0.321	1.23 (1.03, 1.47)	0.019	2.53 (1.78, 3.61)	<0.001	1.26 (1.00, 1.58)	0.051
Adjusted for individual risk factors only[1]								
Low	–		–		–		–	
Mid	2.28 (1.38, 3.77)	0.002	1.09 (0.89, 1.32)	0.390	1.36 (0.97, 1.90)	0.074	1.35 (1.09, 1.68)	0.006
High	1.42 (0.71, 2.85)	0.310	1.15 (0.92, 1.44)	0.197	2.20 (1.48, 3.26)	<0.001	1.26 (0.98, 1.61)	0.070
Adjusted for individual and neighborhood risk factors[2]								
Low	–		–		–		–	
Mid	0.81 (0.47, 1.39)	0.426	1.08 (0.84, 1.38)	0.540	1.90 (0.60, 1.74)	0.924	1.46 (1.20, 1.78)	0.001
High	0.68 (0.30, 1.54)	0.347	1.33 (1.01, 1.74)	0.044	2.46 (1.57, 3,84)	<0.001	1.60 (1.22, 2.11)	0.001

1. Adjusted for sex, age group, education level, smoking, diet, and physical activity.

2. Adjusted for individual factors, as well as neighborhood averages of head of household education level, dependency ratio, head of household employment, and household state assistance.

Table 3 Prevalence ratios for association between neighborhood SES and cardiometabolic outcomes (women)

	Diabetes		Hypertension		High Cholesterol		Obesity	
	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value
Crude								
Low (ref)	–		–		–		–	
Mid	1.52 (0.86, 2.70)	0.146	0.83 (0.51, 1.36)	0.447	1.78 (0.71, 1.95)	0.514	1.29 (0.98, 1.69)	0.067
High	1.49 (0.67, 3.32)	0.324	1.26 (0.96, 1.66)	0.093	2.04 (1.29, 3.23)	0.003	1.14 (0.89, 1.46)	0.280
Adjusted for individual risk factors only[1]								
Low	–		–		–		–	
Mid	1.75 (1.00, 3.08)	0.051	0.85 (0.55, 1.30)	0.443	1.13 (0.73, 1.75)	0.560	1.35 (1.06, 1.73)	0.017
High	1.03 (0.47, 2.26)	0.934	1.03 (0.80, 1.32)	0.819	1.45 (0.88, 2.39)	0.138	1.09 (0.83, 1.43)	0.510
Adjusted for individual and neighborhood risk factors[2]								
Low	–		–		–		–	
Mid	0.74 (0.36, 1.51)	0.393	0.72 (0.44, 1.17)	0.178	1.12 (0.56, 2.23)	0.735	1.30 (1.00, 1.69)	0.053
High	1.10 (0.58, 2.07)	0.762	1.25 (0.95, 1.63)	0.106	1.81 (0.96, 3.40)	0.065	1.32 (1.06, 1.65)	0.015

1. Adjusted for sex, age group, education level, smoking, diet, and physical activity.

2. Adjusted for individual factors, as well as neighborhood averages of head of household education level, dependency ratio, head of household employment, and household state assistance.

Table 4 Prevalence ratios for association between neighborhood SES and cardiometabolic outcomes (men)

	Diabetes		Hypertension		High Cholesterol		Obesity	
	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value
Crude								
Low (ref)	–		–		–		–	
Mid	2.70 (1.03, 7.07)	0.043	1.34 (0.90, 2.00)	0.143	1.87 (0.74, 4.73)	0.177	1.46 (0.72, 2.95)	0.282
High	1.39 (0.58, 3.34)	0.446	1.24 (0.85, 1.82)	0.254	3.83 (1.53, 9.57)	0.005	2.13 (1.15, 3.94)	0.018
Adjusted for individual risk factors only[1]								
Low	–		–		–		–	
Mid	2.28 (1.04, 6.94)	0.042	1.40 (0.98, 2.00)	0.062	1.90 (0.76, 4.72)	0.161	1.52 (0.70, 3.29)	0.276
High	1.73 (0.67, 4.43)	0.248	1.33 (0.89, 1.99)	0.162	3.97 (1.43, 10.97)	0.009	1.83 (0.87, 3.86)	0.107
Adjusted for individual and neighborhood risk factors[2]								
Low	–		–		–		–	
Mid	0.67 (0.22, 2.02)	0.469	2.02 (1.10, 3.71)	0.024	0.99 (0.27, 3.63)	0.983	4.24 (0.69, 26.18)	0.115
High	0.34 (0.08, 1.43)	0.136	1.69 (0.83, 3.45)	0.143	4.70 (1.64, 13.44)	0.005	5.06 (0.74, 34.71)	0.096

1. Adjusted for sex, age group, education level, smoking, diet, and physical activity.

2. Adjusted for individual factors, as well as neighborhood averages of head of household education level, dependency ratio, head of household employment, and household state assistance.

5.0 Discussion

5.1 Burden of Cardiometabolic Outcomes—Our Sample in Context

Our sample reflects the high burden of adverse cardiometabolic outcomes in urban Jamaica relative to global levels. Women were overrepresented in the sample compared to Jamaica population estimates (66.9% vs. 50.5%) (Statistical Insititute of Jamaica, 2012), and more than half of participants were aged 45 or older (56.0%). The prevalence of cardiometabolic outcomes was high but displayed patterns consistent with the findings of other studies in Jamaica and the Caribbean.

Hypertension, the most prevalent outcome, was recorded in 50.5% of participants (women: 53.0%, men: 45.6%), which falls within the range previously reported among Jamaicans aged 18 to 20 (21%, women: 15%, men: 30%) and in the 60+ age group (61.4%, women 72.5%, men: 49.2%) (Mitchell-Fearon et al., 2014). This prevalence exceeds global estimates of hypertension among 31.1% of the world's population (Mills et al., 2016), but is consistent with the ranges reported among adults in Latin America and the Caribbean as a whole (Ordunez et al., 2015) and in Barbados (Howitt et al., 2015), a country with similar socio-demographic makeup to Jamaica. These rates are not dissimilar to hypertension rates among Black adults in the United States (57.1%), which are higher than among White adults in that country (43.6%) (Ostchega et al., 2020).

Obesity was twice as prevalent in women when compared with men in our sample (45.7% vs. 19.4%). This disparity by sex is consistent with previous findings in Jamaica, including an analysis of 2007-2008 national survey data among rural and urban residents aged 15-74 years (women: 37.5%, men: 12.3%) and 2016 estimates reported by PAHO (women: 35.7%, men 18.4%)

(Ferguson et al., 2011; Pan American Health Organization, 2017). However, obesity among women is high in our sample when compared to these other reports—though not as high as rates reported among African American women from 2015 to 2018 (56.2%) (National Center for Health Statistics, 2021). The overall obesity prevalence in our sample (37.0%) was similar to prevalence reported among Barbadian adults (33.8%) (Howitt et al., 2015).

High total cholesterol among participants of the present study was much higher than those of 2007-2008 national survey estimates (women: 34.3% vs. 15.6%, men: 21.7% vs. 7.5%) (Ferguson et al., 2011). While studies on cholesterol prevalence in Jamaica are few, a pooled analysis of population-based studies in Latin America and the Caribbean published between 1964 and 2016 found high total cholesterol among 21% of adults (Carrillo-Larco et al., 2020).

Diabetes is also higher among women than men in both the present study and previously published analyses of urban Jamaica, which contrasts with global patterns in which men have similar or higher prevalence of diabetes. Afro-Caribbean women are almost uniformly at higher risk of diabetes than their male counterparts and are also more likely to be obese and less physically active (Sobers-Grannum et al., 2015). The prevalence of diabetes in our sample (women: 18.2%, men: 16.9%) is higher than 2007-2008 survey estimates that included both rural and urban Jamaicans (women: 9.3%, men: 6.4%), but more similar to rates published from an older urban sample in Spanish Town, Jamaica (women: 15.7%, men: 9.8%) (Ferguson et al., 2011; Wilks et al., 1999). In recent decades, the burden of diabetes among Jamaicans and other Afro-Caribbean adults has consistently exceeded global prevalence rates (Howitt et al., 2015; Saeedi et al., 2019).

5.2 Cardiometabolic Outcomes and Neighborhood SES

Very few studies have examined associations of neighborhood SES with cardiometabolic outcomes among adults in Jamaica. Moreover, known associations have been non-linear with some findings of increased risk in middle or high SES tiers in comparison to low SES (Ferguson et al., 2020; Mendez et al., 2004). The reasons for these associations are not clear, and we hypothesized that adjusting for other neighborhood SES variables would result in a more linear association between lower property prices and poorer cardiometabolic health. However, in analyses unstratified by sex, high neighborhood SES was instead associated with greater prevalence of hypertension (PR = 1.33, p = 0.044) and high cholesterol (PR = 2.46, p <0.001), and both high SES (PR = 1.60, p = <0.001) and middle SES (PR = 1.46, p <0.001) were associated with increased obesity when compared with the lowest SES tiers. In stratified analyses, high SES was associated with more obesity among women (PR = 1.32, p = 0.015) and more high total cholesterol among men (PR = 4.70, p = 0.005). Mid-tier SES was also associated with greater rates of hypertension among men (PR = 2.02, p = 0.024).

Published analyses using the Jamaican Health and Lifestyle Survey 2017-2016 showed that living in lower-SES communities was associated with lower odds of meeting at least five of seven ideal cardiovascular health criteria (ICH-5) among Jamaican men, where SES was defined by median unimproved land value and adjusted for age, education, and household assets (McKenzie et al., 2020). The same study found that educational attainment was inversely associated with ICH-5 among men, though the association was positive among women.

Our finding of mixed relationships between neighborhood SES and some cardiometabolic outcomes is similar to other studies in the Jamaican context that have found increasing hypertension prevalence with income in educated men (Mendez et al., 2003) and increased obesity

among urban middle class Jamaicans who do not reside near public parks (Cunningham-Myrie et al., 2021). Jamaica is an upper-middle income country undergoing an epidemiologic transition and uneven economic development within its urban centers (Henry-Lee, 2005). Nonlinear and unexpected relationships between SES and cardiovascular disease risk factors have been noted in other countries experiencing similar transitions. The findings of the present study are unexpected but explicable in the light of a study of Malaysian adults that found negative associations between hypertension and smoking, and income and education, but no linear pattern in relationships between diabetes, high cholesterol, and overweight with income and education (Rasiah et al., 2013), and a systematic review of non-communicable disease risk factors among low- and middle-income countries which found that the direction of associations changed based on a variety of risk factors, sex, and geographic location (Stringhini & Bovet, 2017). Cardiovascular disease prevalence was also higher among people of higher SES in high income countries in the early 20th century, when smoking, unhealthy diets and sedentary lifestyles were more common among high-income groups (Petrovic et al., 2018; Wilkinson, 1994). Less privileged Jamaicans may face an even greater burden of cardiometabolic outcomes and cardiovascular disease if the same patterns hold in the Caribbean.

5.3 Strengths

A strength of this paper was its use of a population-based sampling approach and survey weighting of regression analyses to produce prevalence ratios that were generalizable to Jamaica's urban population in the southeast region. This study also took into account not only the effects of individual risk factors, but also neighborhood SES characteristics that could affect the relationship

between property prices and cardiovascular health, such as household employment and education levels, dependency ratios, and state assistance. The use of property sales prices was also novel and presents more up-to-date representations of value when compared to unimproved property values reported by the National Land Agency.

5.4 Limitations

While the use of property sales data as our primary SES indicator results in more accurate depictions of property worth when compared to unimproved property values, a consequence of this approach is that properties not sold in the 2003 to 2021 period were not included in the analyses. This limitation may be addressed in future analyses by incorporating both sales price data and unimproved property values. In addition, low-income neighborhoods where informal property ownership is more common may have had fewer property sales. In addition, neighborhood SDC profiles from which household employment and education levels, dependency ratios, and state assistance data were derived were published over a span of 14 years from 2004 to 2017. While this matches the timespan for property data included in our analyses, it also means that SDC data for some neighborhoods is much older than data in other neighborhoods, which may affect comparability. A third limitation is the lack of data about alcohol use, which is an important individual risk factor, and marital status, which may have effects at the individual and neighborhood level.

6.0 Conclusions

Among urban Jamaicans, associations between neighborhood SES and diabetes, hypertension, high cholesterol, and obesity appear to be nonlinear and dependent on sex, individual risk factors, and neighborhood level confounders. We found that urban Jamaican women living in neighborhoods with higher average property prices had a 32% higher prevalence of obesity and urban Jamaican men had 4.7 times the prevalence of high cholesterol when compared to counterparts living in neighborhoods with low property prices, after taking into account individual risk factors and other neighborhood SES characteristics that may affect cardiometabolic health. Men living in neighborhoods with mid-tier property prices had nearly double the prevalence of hypertension in comparison to neighborhoods with lower prices. These findings are plausible in light of Jamaica's epidemiologic transition and nonlinear relationships reported in other low, middle, and upper-middle income countries. However, reasons for mixed results remain unclear. Future research incorporating a wider variety of individual and neighborhood-level SES indicators may be helpful to elucidate these relationships. Understanding relationships between neighborhood SES and adverse cardiometabolic outcomes is key to the public health goal of reducing the disproportionate burden borne by Jamaica and other low- and middle-income countries.

Appendix A Supplemental Tables: Neighborhood SES, Cardiometabolic Outcomes, and Individual Risk Factors

Appendix Table 1 Relative frequencies of cardiometabolic outcomes in relationship to median property sales price

	Low (n=293)	**Mid (n=272)**	**High (n=268)**	**Total (n=833)**	**P-value[1]**
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
Avg. Property Price (Million JMD)	1.0 (0.71)	4.9 (1.8)	17.7 (8.8)	7.7 (8.7)	<0.001
	n (%)	n (%)	n (%)	n (%)	
Women and Men					
Diabetes	40 (16.9)	47 (17.3)	54 (20.1)	134 (16.9)	0.120
Hypertension	149 (50.8)	129 (47.4)	143 (53.4)	421 (50.5)	0.383
High Cholesterol	67 (22.9)	78 (28.7)	106 (39.5)	251 (30.1)	<0.001
Obesity	98 (34.9)	108 (41.4)	90 (34.0)	296 (37.0)	0.210
Women Only					
Diabetes	30 (15.1)	36 (18.6)	35 (21.2)	101 (18.2)	0.321
Hypertension	103 (52.0)	96 (49.5)	96 (58.2)	295 (53.0)	0.245
High Cholesterol	56 (283)	64 (33.0)	71 (43.0)	191 (34.29)	0.012
Obesity	85 (44.3)	95 (50.8)	65 (41.4)	245 (45.7)	0.193
Men Only					
Diabetes	10 (10.5)	11 (14.1)	19 (18.4)	40 (14.5)	0.284
Hypertension	46 (48.4)	33 (42.3)	47 (45.6)	126 (45.6)	0.724
High Cholesterol	11 (11.6)	14 (17.9)	35 (34.0)	60 (21.7)	<0.001
Obesity	13 (14.6)	13 (17.6)	25 (25.0)	51 (19.4)	0.176

1. P-values were calculated using ANOVA and χ^2 tests.

Appendix Table 2 Relative frequencies of cardiometabolic outcomes in relationship to household head education level

	Low (n=260)	Mid (n=233)	High (n=239)	Total (n=732)	P-value[1]
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
% Household heads with at least secondary education	32.8 (7.1)	48.0 (3.9)	59.4 (2.5)	46.3 (12.1)	<0.001
	n (%)	n (%)	n (%)	n (%)	
Women and Men					
Diabetes	50 (19.3)	38 (16.3)	38 (15.9)	126 (17.2)	0.544
Hypertension	121 (46.5)	124 (53.2)	118 (49.4)	363 (49.6)	0.333
High Cholesterol	78 (30.0)	79 (33.9)	64 (26.8)	221 (30.19)	0.240
Obesity	84 (34.8)	84 (37.0)	92 (39.5)	260 (37.1)	0.580
Women Only					
Diabetes	34 (20.7)	25 (15.6)	31 (18.7)	90 (18.4)	0.491
Hypertension	80 (48.5)	92 (57.5)	83 (50.0)	255 (51.9)	0.221
High Cholesterol	59 (35.7)	57 (35.6)	49 (29.5)	165 (33.6)	0.391
Obesity	65 (41.9)	71 (45.8)	80 (49.4)	216 (45.8)	0.413
Men Only					
Diabetes	16 (16.8)	13 (17.8)	7 (9.6)	36 (14.9)	0.303
Hypertension	41 (43.2)	32 (43.8)	35 (47.9)	108 (44.8)	0.809
High Cholesterol	19 (20.0)	22 (30.1)	15 (20.5)	56 (23.24)	0.246
Obesity	19 (22.1)	13 (18.1)	12 (16.9)	44 (19.2)	0.682

1. P-values were calculated using ANOVA and χ^2 tests.

Appendix Table 3 Relative frequencies of cardiometabolic outcomes in relationship to dependency ratio

	Low (n=249)	**Mid (n=250)**	**High (n=237)**	**Total (n=736)**	**P-value[1]**
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
Avg. Dependency Ratio	45.5 (3.0)	52.5 (3.1)	65.2 (6.5)	54.2 (9.3)	<0.001
	n (%)	n (%)	n (%)	n (%)	
Women and Men					
Diabetes	46 (18.5)	43 (17.2)	38 (16.0)	127 (17.3)	0.764
Hypertension	126 (50.6)	130 (52.0)	110 (46.4)	366 (49.73)	0.442
High Cholesterol	91 (36.5)	81 (32.4)	58 (24.5)	230 (31.2)	0.014
Obesity	84 (34.8)	84 (37.0)	92 (39.5)	260 (37.1)	0.580
Women Only					
Diabetes	31 (19.9)	31 (18.1)	28 (16.8)	90 (18.2)	0.770
Hypertension	84 (53.5)	96 (56.1)	79 (47.3)	259 (52.3)	0.250
High Cholesterol	61 (38.8)	68 (38.8)	45 (26.9)	174 (35.1)	0.024
Obesity	59 (38.3)	83 (50.9)	73 (44.8)	215 (45.0)	0.097
Men Only					
Diabetes	15 (16.3)	12 (15.2)	10 (14.3)	37 (15.3)	0.938
Hypertension	42 (45.6)	34 (43.0)	31 (44.3)	107 (44.4)	0.943
High Cholesterol	30 (32.6)	13 (16.5)	13 (18.6)	56 (23.4)	0.024
Obesity	20 (22.22)	12 (17.14)	11 (15.9)	43 (18.8)	0.552

1. P-values were calculated using ANOVA and χ^2 tests.

Appendix Table 4 Relative frequencies of cardiometabolic outcomes in relationship to household head employment

	Low (n=255)	**Mid (n=272)**	**High (n=168)**	**Total (n=695)**	**P-value[1]**
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
% Household heads employed	52.2 (8.0)	63.5 (4.6)	72.4 (1.6)	61.5 (9.7)	<0.001
	n (%)	n (%)	n (%)	n (%)	
Women and Men					
Diabetes	53 (20.8)	50 (18.4)	18 (10.8)	121 (17.4)	0.026
Hypertension	124 (48.6)	54.4 (148)	78 (46.4)	350 (50.4)	0.209
High Cholesterol	85 (33.3)	83 (30.5)	49 (29.2)	217 (31.2)	0.630
Obesity	85 (35.1)	109 (40.8)	56 (35.7)	250 (37.5)	0.256
Women Only					
Diabetes	33 (21.0)	40 (20.6)	14 (12.4)	87 (18.7)	0.137
Hypertension	83 (52.9)	110 (56.7)	54 (47.4)	247 (53.1)	0.284
High Cholesterol	62 (39.5)	64 (33.0)	35 (30.7)	161 (34.6)	0.266
Obesity	66 (44.3)	96 (50.0)	45 (43.0)	208 (46.4)	0.414
Men Only					
Diabetes	20 (20.4)	10 (12.8)	4 (7.4)	34 (14.8)	0.081
Hypertension	41 (41.8)	38 (48.7)	24 (44.4)	103 (44.8)	0.659
High Cholesterol	23 (23.5)	19 (24.4)	14 (25.9)	56 (24.3)	0.945
Obesity	19 (20.4)	13 (17.33)	10 (20.0)	42 (19.3)	0.870

1. P-values were calculated using ANOVA and χ^2 tests.

Appendix Table 5 Relative frequencies of cardiometabolic outcomes in relationship to household state assistance

	Low (n=288)	Mid (n=178)	High (n=193)	Total (n=259)	P-value[1]
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
% Household receiving state assistance	6.4 (1.7)	11.9 (2.2)	20.1 (2.4)	11.9 (6.1)	<0.001
	n (%)	n (%)	n (%)	n (%)	
Women and Men					
Diabetes	45 (15.6)	41 (23.0)	30 (15.4)	116 (17.6)	0.084
Hypertension	150 (52.1)	86 (48.3)	96 (49.7)	332 (50.4)	0.716
High Cholesterol	89 (30.9)	59 (33.1)	55 (28.5)	203 (30.8)	0.625
Obesity	105 (37.5)	67 (38.1)	64 (36.6)	236 (37.4)	0.958
Women Only					
Diabetes	34 (16.4)	28 (23.9)	20 (16.7)	82 (18.5)	0.207
Hypertension	111 (53.6)	64 (54.7)	59 (49.2)	234 (52.7)	0.651
High Cholesterol	71 (32.3)	43 (36.7)	41 (34.2)	155 (34.9)	0.888
Obesity	91 (45.3)	55 (47.8)	50 (45.0)	196 (45.9)	0.889
Men Only					
Diabetes	11 (13.6)	13 (21.3)	10 (13.7)	34 (15.8)	0.380
Hypertension	39 (48.1)	22 (36.1)	37 (50.7)	98 (45.6)	0.201
High Cholesterol	18 (22.2)	16 (26.2)	14 (19.2)	48 (22.3)	0.621
Obesity	14 (17.7)	12 (29.7)	14 (21.9)	40 (19.6)	0.824

1. P-values were calculated using ANOVA and χ^2 tests.

Appendix Table 6 Distribution of individual risk factors in relationship to SES as determined by median property sales price

Neighborhood SES	Low (n=293)	Mid (n=272)	High (n=268)	Total (n=833)	P-value[1]
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	
Avg. property price (Million JMD)	1.0 (0.71)	4.9 (1.8)	17.7 (8.8)	7.7 (8.7)	
	n (%)	n (%)	n (%)	n (%)	
Age group					0.015*
Age <25	41 (14.0)	47 (17.3)	28 (10.4)	116 (13.9)	
Age ≥25 & <45	98 (33.4)	77 (28.3)	75 (28.0)	250 (30.0)	
Age ≥ 45 & <65	100 (34.1)	101 (37.1)	90 (33.6)	291 (34.9)	
Age ≥65	54 (18.4)	47 (17.3)	75 (28.0)	176 (21.1)	
Educational attainment					<0.001*
Less than high school	67 (23.3)	66 (24.3)	50 (18.9)	183 (22.2)	
High school	176 (61.3)	153 (56.5)	100 (37.7)	429 (52.1)	
More than high school	44 (15.3)	52 (19.2)	115 (43.4)	211 (25.6)	
Adequate physical activity (≥150 min moderate or 75 min vigorous activity / week)	155 (46.9)	111 (41.1)	110 (42.0)	376 (45.6)	0.006*
Healthy diet (≥3 of 4 dietary factors)[2]	60 (20.5)	40 (14.7)	93 (34.7)	193 (27.2)	<0.001*
Current smoker	64 (21.8)	53 (19.5)	25 (9.33)	142 (17.0)	<0.001*

*Statistically significant differences in characteristics among participants living in different property price tiers ($p < 0.05$)

1. P-values were calculated using χ^2 tests.

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