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THE EPIDEMIOLOGY AND BURDEN OF CARDIOMETABOLIC RISK FACTORS IN A YOUNG EMIRATI POPULATION

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This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Under the Supervision of Dr. Luai A. Ahmed

April 2020

Declaration of Original Work

I, Fatima Abobakr Hussein Mezhal, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this thesis entitled "*The Epidemiology and Burden of Cardiometabolic Risk Factors in a Young Emirati Population*", hereby, solemnly declare that this thesis is my own original research work that has been done and prepared by me under the supervision of Dr. Luai A. Ahmed, in the College of Medicine and Health Sciences at UAEU. This work has not previously been presented or published, or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my thesis have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this thesis.

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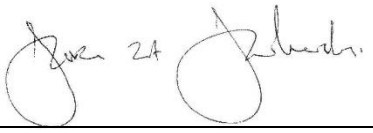
Signature  Date March 4, 2021

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Abstract

The United Arab Emirates (UAE) has experienced a rapid economic growth that was paralleled with a drastic rise in non-communicable diseases (NCDs); primarily cardiovascular diseases (CVDs), which account for 40% of mortality in UAE. CVDs have complex etiology, interplay and accumulation of many risk factors. Understanding the clustering and interrelationships between common risk factors like obesity, dysglycemia, dyslipidemia, hypertension and central obesity, and the associations with social and lifestyle determinants, is warranted. The study aimed to estimate the burden of cardiometabolic risk factors (CRFs), their interrelationship, and their associations with other social and lifestyle determinants in a young Emirati population. Data was drawn from the UAE Healthy Future Study collected between 2016 and 2018. The information was collected through questionnaires, physical measurements and blood samples. Age-adjusted and gender-specific prevalence of CRFs were estimated, and appropriate regression models were used to determine the interrelationships and associations of the CRFs. A total of 5,167 eligible participants aged 18-40 were included in the analysis. The age-adjusted prevalence rates were 26.5% for obesity, 11.7% for dysglycemia, 62.7% for dyslipidemia, 22.4% for hypertension and 22.5% for central obesity. Dyslipidemia had the highest comorbidity rate, up to 80%, with other CRFs, followed by obesity. Obesity had the strongest interrelationship with other CRFs. Education, employment, smoking and family history of NCDs had significant associations with some CRFs. Forty percent of the population had ≥2 CRFs, and the accumulation was higher in men than women; 47.8% vs 28.1%, respectively. The burden of CRFs was affected by age and social factors, and was significantly different across BMI classes. CRFs and their clustering are highly prevalent in young adults, including those of normal BMI. This should be taken into account in the design and targeting of group-specific measures for CVDs and other NCDs prevention. Further research is needed to investigate how the clustering manifests in young adults to prevent the early rise of NCDs in the UAE.

Keywords: Non-communicable disease, Cardiovascular disease, Cardiometabolic risk factors, Obesity, Dysglycemia, Dyslipidemia, Hypertension, Central obesity.

Title and Abstract (in Arabic)

انتشار وعبء عوامل مخاطر الإصابة بالأمراض القلبية عند الإماراتيين الشباب

الملخص

شهدت دولة الإمارات نمواً سريعاً في الاقتصاد، وواكب هذا النمو ارتفاع حاد في الأمراض غير المعدية؛ حيث تعد أمراض القلب والأوعية الدموية في المقام الأول، والتي تمثل 40% من أسباب الوفيات في دولة الإمارات العربية المتحدة. وعلاوة على ذلك، فإن هذه الأمراض القلبية الوعائية لها مسببات متعددة العوامل ومعقدة. لذلك يتوجب علينا فهم التكتل والعلاقات المتبادلة بين عوامل الخطر المنتشرة مثل السمنة وسكر الدم وارتفاع نسبة الدهون فالدم وارتفاع ضغط الدم والسمنة المركزية، ومن المهم فهم ارتباطها بالعوامل الاجتماعية الأخرى ومحددات نمط الحياة. هدفت هذه الدراسة إلى تقدير عبء عوامل الخطر القلبية والتحقيق في ترابطها مع بعضها البعض، وارتباطها بالعوامل الاجتماعية ومحددات نمط الحياة الأخرى في الإماراتيين الشباب. تم استخلاص البيانات من دراسة "مستقبل صحي للإمارات" التي تم جمعها بين عامي 2016 و2018، حيث تم جمع المعلومات من خلال استبيانات وقياسات بدنية وعينات الدم. قُدِّر عبء عوامل الخطر لكل فرد، وقُدِّر معدل انتشار هذه المعدلات حسب العمر والجنس، واستُخدمت نماذج الانحدار اللازمة لتحديد العلاقات المتبادلة بين هذه العوامل وارتباطاتها بالعوامل الأخرى. شمل التحليل 5,126 مشاركاً من 40-18 سنة وكانت معدلات الانتشار المعدلة حسب العمر 26.5٪ للسمنة، و11.7٪ لسكر الدم، 62.7٪ لارتفاع الدهون فالدم، و22.4% لارتفاع ضغط الدم و22.5٪ للسمنة المركزية. كان ارتفاع نسبة الدهون فالدم أكثر عامل خطر تواجد مع غيره من العوامل لحد 80% من الوقت، ويتلوه السمنة المفرطة. وكان للسمنة أقوى علاقة مترابطة مع عوامل الخطر الأخرى. أثبتنا أن لأحوال التعليم والعمل والتدخين والتاريخ الأسري للأمراض غير المعدية له روابط كبيرة مع بعض عوامل الخطر المذكورة. ووجدنا أن 40% من شريحة الشباب يراكمون أكثر من عاملي خطر في آن واحد، وكانت نسبة التراكم أعلى بين الذكور على الإناث 47.8% مقابل 28.1%. تأثر التراكم بشكل كبير بالعمر والعوامل الاجتماعية. وكان عبء التراكم لعوامل الخطر مختلفاً بشكل كبير عبر فئات مؤشر كتلة الجسم. إن ارتفاع عوامل الخطر للأمراض القلبية وتراكمها أصبح خطراً يهدد بشكل كبير فئة الشباب في دولة الإمارات العربية المتحدة حتى من هم دون ارتفاع الوزن المفرط. ويتأثر عبء وتجميع عوامل الخطر هذه بالعمر ونوع الجنس والتعليم والعمالة والتدخين والتاريخ الأسري للأمراض غير المعدية. وينبغي أن يؤخذ ذلك في عين الاعتبار عند تصميم واستهداف التدابير الخاصة بكل مجموعة للوقاية من الأمراض القلبية الوعائية بصفة خاصة وغيرها من الأمراض غير المعدية بوجه عام. وثمة حاجة

إلى إجراء مزيد من البحوث للتحقيق في كيفية ظهورها بين الشباب لمنع الزيادة المبكرة للأمراض غير المعدية في الإمارات العربية المتحدة.

مفاهيم البحث الرئيسية: الأمراض غير المعدية، أمراض القلب والأوعية الدموية، عوامل الخطر القلبية، السمنة المفرطة، سكر الدم، ارتفاع نسبة الدهون فالدم، ارتفاع ضغط الدم، السمنة المركزية.

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My deep appreciation for my family and friends for their love and encouragement to pursue my dreams.

And most importantly, Allah for giving me the opportunity, determination and strength to pursue this research.

Dedication

This dissertation is dedicated to my Mother – whose love, support and encouragement inspired me to pursue- and achieve-my dreams.

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List of Abbreviations

ATP3	Adult Treatment Panel 3
BMI	Body Mass Index
CDC	Centers of Disease Control and Prevention
CHD	Coronary Heart Disease
Chol	Cholesterol
CI	Confidence Interval
CRFs	Cardiometabolic Risk Factors
CVD	Cardiovascular Disease
DBP	Diastolic Blood Pressure
GDP	Gross Domestic Product
GPAQ	Global Physical Activity Questionnaire
HbA1c	Hemoglobin A1C
HBP	High Blood Pressure
HDL	High Density Lipoprotein
IDF	International Diabetes Federation
LDL	Low Density Lipoprotein
METs	Metabolic Equivalents
MetS	Metabolic Syndrome
MRFs	Metabolic Risk Factors
NCD	Noncommunicable Disease
OR	Odd Ratio
PA	Physical Activity
RF	Risk Factors
SBP	Systolic Blood Pressure
SES	Socioeconomic Status

T2D	Type 2 Diabetes
TG	Triglycerides
UAE	United Arab Emirates
UAEHFS	UAE Healthy Future Study
WHO	World Health Organization
WHR	Waist-to-Hip Ratio
Wk	Week
YLDs	Years Lived with Disability
YLLs	Years of Life Lost
Yrs	Years

Chapter 1: Introduction

1.1 The United Arab Emirates

The United Arab Emirates (UAE) is a young country, founded in 1971 by the late Sheikh Zayed Bin Sultan Al Nahyan. This 47-year-old country is part of the 6 Gulf Cooperation Council countries, situated in the southeast of the Arabian Peninsula in southwest Asia on the Arabian Gulf, Figure 1. The UAE, similar to the neighboring countries, experienced an economic reformation after the discovery and use of their oil and gas resources.

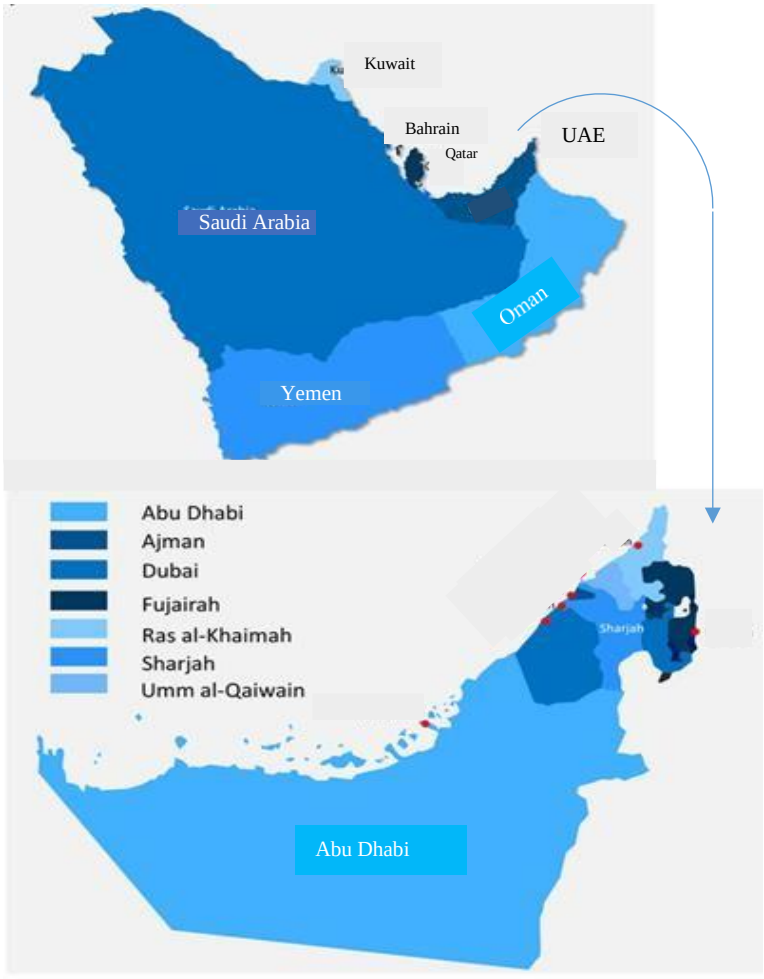


Figure 1: The geography and map of the UAE

The total area of the country is 83,600 square kilometers with a population of 9.5 million (1). It consists of seven states; Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al-Quwain and Fujairah. Abu Dhabi Emirate, is the largest Emirate accounting for 87 percent of the total land area. Abu Dhabi has the second largest population, after Dubai, it is estimated to be around 2 million people where 20% or 550 thousand are Emirati citizens. Dubai, on the other hand, is 4,114 square kilometers and 2.5 million people reside in this city. The proportion of Emiratis in the country is 11.5%. The UAE population is majorly young. Figure 2 displays Abu Dhabi's unique age distribution of the Emirati population (2).

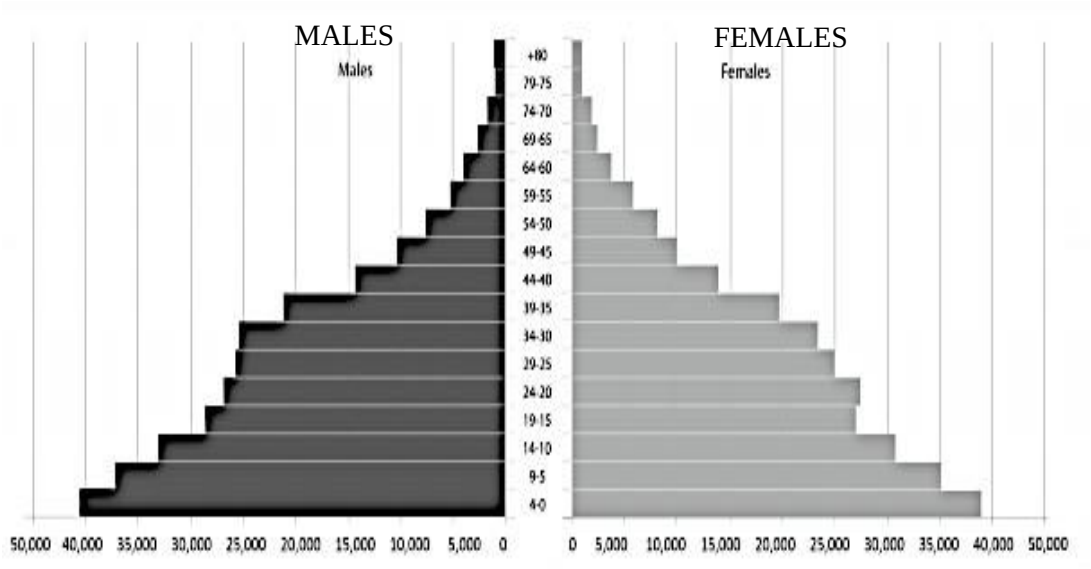


Figure 2: Abu Dhabi's Emirati population by age

The economic burst of the UAE, along with the political and diplomatic strategies with countries all over the world, transformed the country from a developing country to one of the most developed countries in the world, with happy and contented citizens and residents. In 2014, it was noted that the gross domestic product (GDP) of the UAE increased from AED 6.5 billion in 1971 to AED 1.54 trillion. The World Bank classifies the UAE as a high-income developed country (1). The World

Happiness Report (2016-2018) ranked the UAE as number 21 based on their happiness indicators (3).

The Human Development Index shows the progress the UAE has made in health, education and income over the last few decades (4). The UAE has moved up the worldwide index scale from the 62nd place to 30th with a score that exceeded that of Europe's as whole. Today, educational attainment is very high with less than 5% being illiterate.

The experienced economic and industrial development resulted in the wealth of the national population. This caused a parallel shift from a traditional lifestyle to a more modernized and urbanized lifestyle, that is characterized by reduced physical activity and increased consumption of energy-dense food. Consequently, an increase in rates of obesity and other risk factors was coupled with a rise in noncommunicable diseases (NCDs). NCDs are conditions that do not result from an acute infection, and therefore not infectious or "communicable". These diseases are chronic and are not cured spontaneously. The characteristics of this group of diseases are complex, have a long latency period, prolonged course of illness and cause functional impairment of disability.

1.2 Health in UAE

The life expectancy at birth in the UAE surged to exceed 76 years. Mortality figures, such as infant, child and maternal mortality rates have improved significantly from the 70s and 90s to 2010 (5). Causes of premature death and causes of disability have shuffled across the decades. In the 90s, communicable diseases were in the top ranks as causes of death, however, decades later in 2017, NCDs, such as cardiovascular diseases, diabetes, cancer and musculoskeletal disorders took over. The World Health Organization (WHO) reports that non-communicable diseases (NCDs) account for

77% of all deaths in UAE (6). From all deaths, cardiovascular diseases account for 40% of the causes, followed by injuries, cancers, and diabetes mellitus. A summary on the UAE's health profile is presented in Figure 3.

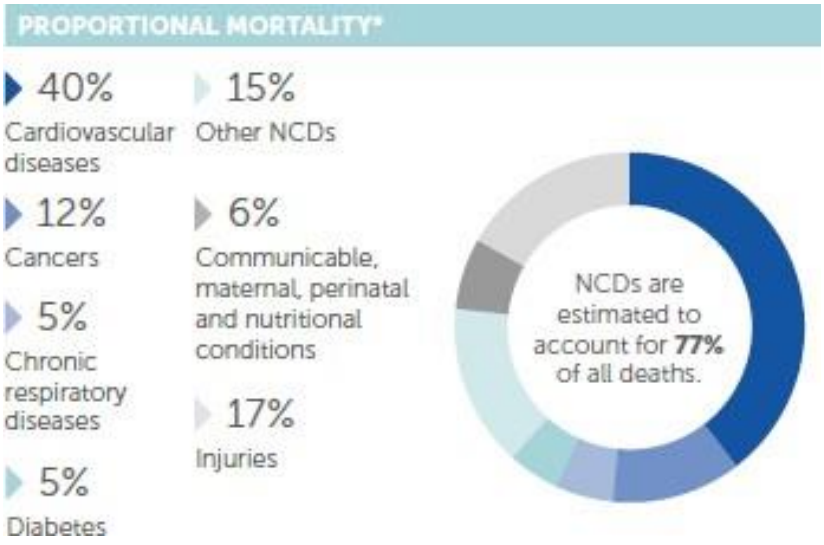


Figure 3: UAE's causes of death

1.3 Heart disease – the number 1 cause of death in UAE

Heart diseases, or cardiovascular diseases (CVDs), are a group of disorders of the heart and blood vessels (7). They can be coronary heart disease, cerebrovascular disease, peripheral arterial disease, or deep vein thrombosis, the types of CVDs are illustrated in Figure 4. Other forms of CVDs can be congenital, called congenital heart disease or can be caused by a bacterial infection, called rheumatic heart disease. Heart attacks and strokes are usually acute events that are caused by accumulated plaque in veins blocking blood flow to the heart or brain.

CVDs are the number 1 cause of death in the world (8). Globally, it is estimated that almost 18 million people died of CVD in 2016, which represent 31% of all deaths worldwide. The most common CVDs that lead to death are heart attack and stroke. Majority of the CVD deaths occur in low- and middle- income countries. Such diseases

are preventable by addressing modifiable behavioral risk factors. Such risk factors include tobacco use, unhealthy diet, physical inactivity and obesity.

CVD is common in the UAE. Loney et al. reported that the UAE has one of the highest age-standardized death rates for CVD in the world, 308.9 per 100,000 for males and 203.9 per 100,000 for females (9). Figure 5 compares the trend in age-adjusted prevalence and incidence rates between Global rates and the UAE. The Statistical Center in Abu Dhabi reported that the death rate by cardiovascular diseases is 39.7 per 100,000 (10). The ministry of Health and Prevention report (2019) revealed that cardiovascular disease-related deaths were attributable to acute myocardial infarction by 22%, followed by cerebrovascular disease, ischemic heart disease and hypertension (11). A recent report by Al shamsi et al. reported the incidence of CVD in high risk individuals to be 12.7 per 1000 person years (12). Yusufali observed that UAE has a higher prevalence of CVD risk factors as opposed to other developed countries with the deaths in UAE being above average (13).

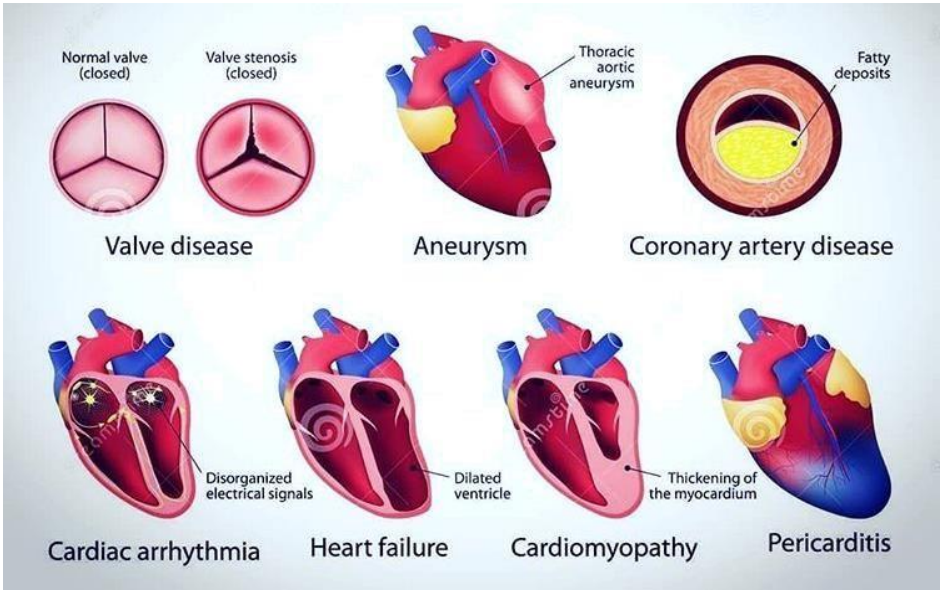


Figure 4: Types of cardiovascular diseases (14)

1.4 Diabetes

Diabetes is a chronic disease that arises when the pancreas does not produce enough insulin or when the body cannot effectively uptake the insulin. Insulin is a hormone that regulates blood sugar. In diabetes, raised blood sugar, or hyperglycemia, happens. When this phenomenon persists over time, it may lead to serious damage in other body systems and complications. There are 2 types of diabetes; type 1, which is also called as juvenile or childhood-onset, as it arises in childhood due to deficient insulin production and the etiology is not known. Type 2 diabetes (T2D), also called as adult-onset, results from the body's insensitivity to insulin. A third type of diabetes is gestational diabetes, is hyperglycemia during pregnancy. An intermediate phase between normal and diabetic is called pre-diabetes or impaired glucose tolerance and impaired fasting glycaemia. This intermediate phase serves as a transitional phase where the blood glucose is higher than normal but below the diagnostic value for diabetes definition. People at this phase are at high risk for T2D but can avoid developing the disease by the appropriate intervention, such as up taking a healthy diet, physical activity, avoiding tobacco use, and regular screening and taking medication.

Diabetes numbers have risen from 108 million in the 1980s to 422 million in 2014 (15). The prevalence is rising rapidly in middle- and low- income countries. In 2016, it was estimated that 1.6 million deaths were caused by diabetes. Globally, diabetes sits on the 7th rank as leading cause of death. Other consequences include blindness, kidney failure, heart attacks, stroke and lower limb amputation.

Type 2 diabetes (T2D) is a major public health concern in the UAE. The International Diabetes Federation ranks four Arab countries in the top 10 globally, where the United Arab Emirates (UAE) stands on the 8th position on the list, with more than 1 million cases (16). Figure 5 displays the difference in prevalence and incidence rates for diabetes globally and in the UAE. A population-wide screening program conducted in Abu Dhabi Emirate, estimated the prevalence of T2D as 18% in adults and 27% had prediabetes (17). Age-standardized diabetes and pre-diabetes prevalence rates were 25% and 30%, respectively (18). In the National Diabetes Guidelines of 2009, it was reported that T2D prevalence rates reached 19.6% in total, with 24% in UAE nationals (19). These high rates are threatening, especially in a young population like the UAE's.

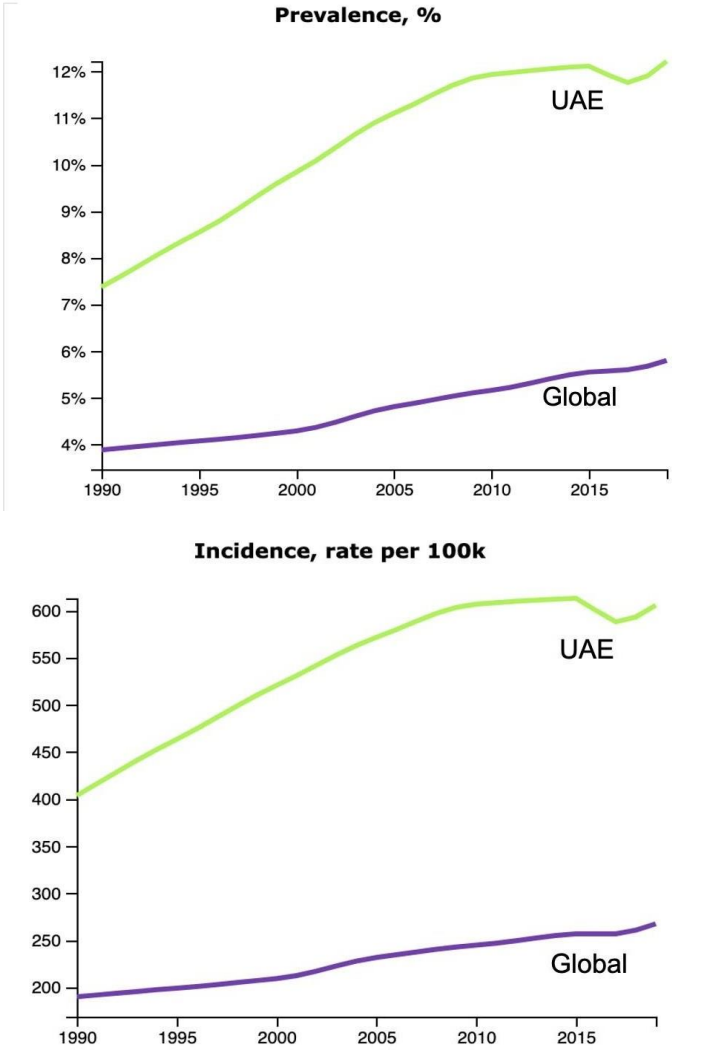


Figure 5: Overall age-adjusted global and local prevalence and incidence rates of Diabetes Mellitus (1990-2017). Global Burden of Disease tool

1.5 Risk factors

NCDs are caused by multiple risk factors. The term "Risk Factor" is defined as "an aspect of personal behavior or lifestyle, an environmental exposure, or a hereditary characteristic that is associated with an increase in the occurrence of a particular disease, injury, or a health condition" (20).

Risk factors can be modifiable or unmodifiable. Modifiable risk factors are those that can be reduced or controlled by intervention, they include among others, physical inactivity, tobacco use, alcohol use, and unhealthy diets. Unmodifiable risk factors are factors that cannot be reduced or controlled by intervention, for instance,

age, gender, race, and genetics. The term “metabolic” refer to the biochemical processes involved in the body’s function, or metabolism. Metabolic risk factors include raised blood pressure, raised blood lipids levels, elevated blood glucose levels and overweight and obesity. These risk factors are considered “intermediate” or secondary to modifiable and unmodifiable risk factors. Eventually, metabolic risk factors lead to the main chronic diseases; like cardiovascular diseases, and diabetes.

There are other risk factors found to be linked with chronic diseases and are being studied immensely worldwide. These include the social factors; which include education, employment, living conditions and family parity. Mental health and psychosocial stress are also considered factors playing role in disease development. Other examples of risk factors include alcohol use, medications like chronic use of Nonsteroidal anti-inflammatory drugs (NSAIDs), women’s health, inflammatory markers, coagulation, sleep patterns, vitamins and the list keep growing with new discoveries to links to chronic diseases.

The INTERHEART study, which included data from 52 countries across the world, showed that smoking, hypertension, high lipoprotein levels, and diabetes accounted for 76% of the risk of myocardial infarction (21). Other large cohort studies have also concluded that CVDs are affected by these same main risk factors; smoking, diabetes, hyperlipidemia, and hypertension (22).

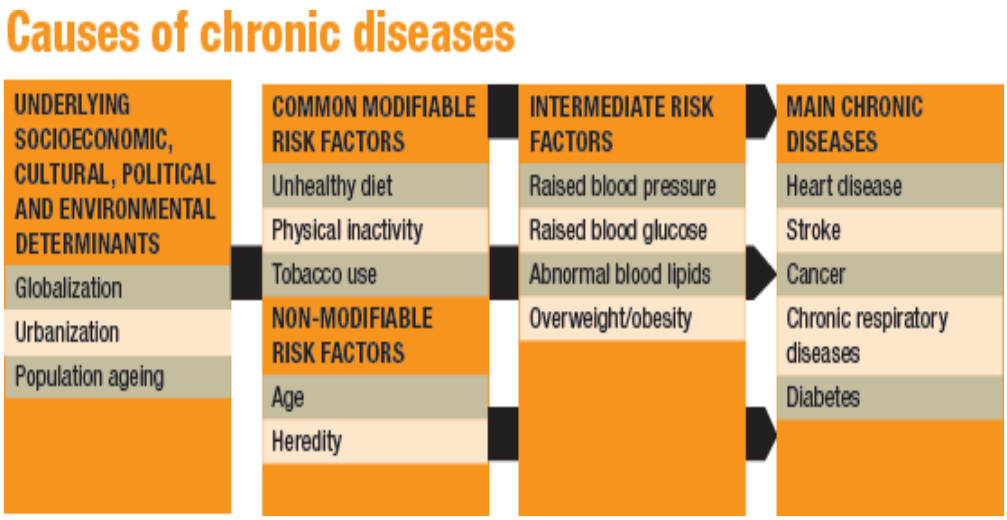


Figure 6: Causes of chronic diseases (23)

People who develop coronary heart disease typically have more than one risk factor. The clustering of cardiovascular risk factors begins in youth, young adulthood and middle age (24, 25). The presence of multiple risk factors simultaneously has been showed to increase the risk for atherosclerosis development in young and middle-aged adults and risk of cardiovascular disease in middle age. CARDIA study estimated that accumulating three or more risk factors were associated with around 2.4-fold increase in men and 6-fold increase in women in the risk of coronary heart disease after 20 years of follow-up (26). Another study showed that accumulating three or more risk factors increased the relative risk of developing cardiovascular events from 2.07 (CI 1.86-2.30) to 2.80 (CI 2.48-3.17) when compared to having one risk factor only, in a 6-year follow up (27). According to country incomes, it was concluded that high income countries had a larger accumulation of cardiovascular risk factors (28).

Interrelationships between pairs of risk factors have been studied previously. Weight increase was reported to be associated with hyperlipidemia, glycaemia, and hypertension in young adults (29). Hypertension was reported to be associated with diabetes (30). In addition, insulin resistance was associated with hypertension, and the

opposite relationship was established as well (31). Other studies reported an increase in incident diabetes and hypertension following dyslipidemia (32, 33) .

A Chinese study assessed the effect of lifestyle on the clustering of risk factors (34). It reported that drinking, physical inactivity and the chronic use of NSAIDs were associated with the accumulation of cardiovascular risk factors. Drinking increased the risk by 60%, physical inactivity by 20% and NSAIDs by 2.17-folds. Another study showed that accumulating risk factors were higher in males and increased with age (35). The study concluded that interventions should be directed towards the elderly and people with lower levels of socioeconomic status.

Multiple studies have examined the clustering of risk factors in the context of metabolic syndrome. Metabolic syndrome describes a combination of risk factors that increase the risk of developing heart disease, stroke, and type 2 diabetes. The National Cholesterol Education Program's Adult Treatment Panel 3 (ATP3) identified metabolic syndrome as a multiplex risk factor for cardiovascular disease that is deserving of more clinical attention (36).

In the UAE, only one study described the accumulation of cardiometabolic risk factors in local population (37). This study was based on military men aged 18-29. Other studies in the UAE that focused on cardiometabolic risk factors accumulation were in the context of metabolic syndrome in expatriates, children and adolescents, or in a specific gender (38-40).

Chapter 2: Research Problem and Objectives

2.1 Research Problem

The UAE's rapid urbanization is paralleled by the rise of burden of chronic noncommunicable diseases (NCDs). NCDs are a cause of great concern in developed and developing countries. These diseases are caused by the complex interplay of external factors and genetic predisposition. Many factors, modifiable and non-modifiable, are reported to have associations with NCD development and pathogenesis. These factors range from the individual's health status and family history to social factors and lifestyle elements.

NCDs are most commonly attributable to cardiometabolic risk factors such as obesity, hyperglycemia, dyslipidemia, high-blood pressure, and central obesity as well as behavioral risk factors such as lack of physical activity and smoking. Socioeconomic factors and family history of disease also play a big role in the development of NCDs. The prevalence of the cardiometabolic risk factors associated with NCDs has increased in the UAE and will continue to increase, as demonstrated by many studies and predicted by projections and future estimates.

Since NCDs are caused by the interplay of risk factors and their accumulation, it is important to study how these risk factors accumulate before a chronic disease is established. The majority of local research studied the risk factors only individually. Most of the epidemiological studies are pre-dated and are either very city specific or only recruited patients from specific healthcare settings. Moreover, only few reports have measured the burden of the risk factors. And only fewer studies focused on young adults, although it has been established that chronic diseases started showing in younger adults, both world-wide and nationally. Finally, no reports have estimated the effect of social, lifestyle and family history determinants on cardiometabolic risk

factors in UAE. This thesis aimed to address the prevalence of cardiometabolic risk factors and their burden in a large sample of young adults and to study how the social and behavioral determinants play a role in cardiometabolic abnormalities.

2.2 Research Objectives

The primary aim of this project is to address the epidemiology and burden of cardiometabolic risk factors causing NCDs, primarily cardiovascular diseases, in a sample of young Emiratis aged 18 to 40 years. The project has the following three objectives.

The first objective was to describe the distribution of cardiometabolic risk factors in this population by:

- Estimating the crude and age-adjusted prevalence for each cardiometabolic risk factor by age, gender, social and behavioral determinants
- Describing the comorbidity of these risk factors; which risk factors co-exist with others most of the time.
- Describing the associations among the cardiometabolic risk factors, and with the other social and behavioral determinants.

The second objective was to describe the burden of cardiometabolic risk factors by:

- Describing the prevalence of accumulated risk factors for each individual.
- Estimating the proportions of people having two or more risk factors by age and gender.
- Investigating the associations between specific social and behavioral determinants and the burden of having two or more risk factors.

The third objective was to investigate the effect of BMI on the other cardiometabolic risk factors and their burden by:

- Describing the distribution of each cardiometabolic risk factor within BMI classes by age and gender.
- Describing the burden of cardiometabolic risk factors by BMI classes.
- Investigating the associations between specific social and behavioral determinants and the burden of having two or more risk factors in each BMI class.

Chapter 3: Literature Review

3.1 The cardiometabolic risk factors

Cardiovascular disease (CVD) is the leading cause of mortality worldwide. In UAE, 40% of the deaths are attributable to CVDs (7). A recent study estimated the incidence is 12.7 per 1000 person-years, 16.8% in men and 9.0 in women (12). The main causes of cardiovascular disease can be grouped as cardiometabolic risk factors, and they include obesity, dysglycemia, dyslipidemia, hypertension, and central obesity. These cardiometabolic risk factors are affected by modifiable and unmodifiable causes. Modifiable risk factors include behavioral or lifestyle factors like smoking and physical inactivity. While unmodifiable risk factors include aging and family history of NCDs. This chapter reviews the literature on the mentioned risk factors pertaining to cardiovascular disease in UAE.

3.1.1 Obesity

According to National Clinical Guideline Center, obesity is defined through measurement of Body Mass Index (BMI) with the report showing the rates of prevalence of obesity being in an increasing trend (41). Chan and Woo defined obesity as a condition of abnormal or excess fat accumulation in adipose tissue leading to health impairment with the BMI being the population-level measure of obesity (42). In the contemporary health care sector, obesity cases represent increasing issues contributing to significant health and social difficulties among global populations. The increasing trend on prevalence is supported by WHO report (43). The report observed that global obesity has almost tripled since 1975, with 30% of adults aged 18 years and above being overweight as at 2016 and 13% being obese. This is also evident among the children where 41 million children globally being obese in 2016.

Despite the aetiology of obesity being ill-understood, Torres and Nowson noted that its pathology is based on an increased chronic intake over caloric expenditure leading to a net gain in calories which is later stored in form of excess fat in adipose tissues (44). This condition as noted by National Clinical Guideline Center is directly associated with different conditions such as type 2 diabetes, hypertension, gallstones and gastro-oesophagal reflux disease and other psychological and psychiatric morbidities (41). To affirm this, the Health and Social Care Information Center in the UK had reported that a total of 11,740 inpatients admissions were as a consequence of a primary diagnosis of obesity in 2011/2012 (45). This is an indicator that obesity has an immense implication on the well-being of people in modern society.

From an international perspective, obesity epidemic drives up the burden levels of general non-communicable diseases (NCDs) with more than 40% prevalence rates (46, 47). This is affirmed by the WHO report that had ranked obesity as a modifiable risk factor of major NCDs (43). In particular, a report had noted that for the adults aged between 40 and 59 years with obesity, they suffer from 21 to 85% increased risk of developing cardiovascular disease and diabetes as opposed to normal weight peers (48). The report that profiled noncommunicable diseases using country profiles of 2018 equally noted that obesity is linked to an increased risk of hypertension and many NCDs including diabetes, coronary heart disease, stroke and cancers and conditions such as obstructive sleep apnoea and osteoarthritis. In this case, individuals suffering from obesity opting for gastric bypass surgery have an overall 33% reduction in death rate hence the weight loss being directly linked with a decrease in mortality (49). This is with obesity leading to an increased risk of more than 13 types of cancer with more than 630,000 individuals in USA diagnosed with cancer linked with obesity in 2014 and a significant increase with 7% as at 2014 (50). According to Webber et al. 60%

of the NCDs are as a consequence of obesity which directly contributes to health concern on individual quality of life, their longevity or lifespan and costs of their health systems (46).

Despite obesity increasing substantially as the affected individual ages, there is no specific age that obesity occurs or elicits health implications. Kranjac and Wagmiller, for instance, pointed out that childhood obesity trends in developed countries indicate that 10% of all obesity cases arise from childhood (51). Kim et al. on the other hand pointed on the adolescent and elderly obesity which equally has a significant implication in the overall obesity cases prevalence (52). In terms of gender nevertheless, some studies have pointed out that females have a higher prevalence of obesity as opposed to males (53). This view is supported by Alhyas et al. which noted that globally, the BMI of adults has significantly increased between 1980 and 2013 from 28.8% to 36.9% in males and 29.8% to 38.0% for the females (54). This particularly is an influence of the differential fat distribution and the pathophysiology of the obesity cases.

In the past decade, UAE has reported an increased prevalence of obesity (55). This is supported by a systematic review that concluded that the cardiovascular diseases and noncommunicable diseases are directly caused by obesity as a primary public health priority (9). In UAE, the obesity prevalence has been investigated through the adoption of distinct strategies for BMI interpretation that show its prevalence levels. Sulaiman et al. noted that in a study done in UAE over 15 years, a third of the population had obesity with more than 40% being overweight (56). The high prevalence of obesity in UAE is also associated with increased cases of NCDs. For instance, it observed that the risk ratios of type 2 diabetes and hypertension have increased at a greater rate as opposed to other GCC states (56). This is on top of the

increasing prevalence of both diabetes and high cholesterol levels in UAE particularly among the individuals suffering from obesity.

3.1.2 Dysglycemia

Dysglycemia is a term that refers to an abnormality in blood sugar levels. It includes hyperglycemia, which is prediabetes and type 2 diabetes. It also includes hypoglycemia or low blood sugar as well (57). Dysglycemia is a widely-spread disease globally and is increasing at an alarming rate. Prediabetes is the intermediate phase of hyperglycemia – where blood sugar is above normal but below the diabetes cut-off. The diagnostic criteria are different across guidelines and countries, however it still remains a high risk state for developing diabetes (58). The yearly conversion rate from prediabetes to diabetes is 5-10%. The CDC reports that 1 in 5 adolescents and 1 in 4 young adults are living with prediabetes (59). Interventional studies showed efficacy in diabetes prevention with a relative risk reduction of 40%-70% in adults with prediabetes. The CDC National Diabetes Statistics Report suggested that 37% of American adults above 20 years and 51% of above 65 had prediabetes in 2009-2012 defined by fasting glucose or HbA1c levels (60).

Diabetes is a group of metabolic diseases that is characterized by chronic hyperglycemia resulting from a defect in insulin secretion, insulin uptake, or both. Diabetes Mellitus is labeled as “The epidemic of the century” because it is rising to an alarming epidemic level. Like other NCDs, it involves the interaction between genetic and environmental factors. Diabetes numbers have risen from 108 million in the 1980s to 422 million in 2014 (15). The prevalence is rising rapidly in middle- and low-income countries. In 2016, it was estimated that 1.6 million deaths were caused by diabetes. Globally, diabetes sits on the 7th rank as leading cause of death.

The global prevalence of diabetes according to the International Diabetes Federation (IDF) was 8.3% in 2013 (61). And the number is expected to rise beyond 592 million by 2035 with a 10.1% global prevalence (62). The Middle East and North Africa region has the highest prevalence of diabetes (10.9%). Low- and middle-income countries count for 80% of the cases.

Diabetes has been associated with cardiovascular diseases. Patients with diabetes have 2 to 4 times increased risk of cardiovascular morbidity and 1.5 to 3.6 increase in mortality (63). Moreover, as noted by WHO cardiovascular disease is widely prevalent among the diabetic patients (64). Interventional as well as epidemiological studies have also shown that cardiovascular risk factors are present with pre-diabetic or hyperglycemic patients (65). According to International Diabetes Federation (IDF), people who have diabetes are two or three times more likely to get cardiovascular diseases (66). The report published by IDF also noted that 2 to 27 middle-aged individuals among 1000 with type 2 diabetes or other unspecified diabetes died from cardiovascular diseases.

Ageing is a major risk factor for diabetes. Central obesity and insulin resistance are preconditions of diabetes and are frequently found in older individuals. Ageing and diabetes can also be related to the decline in lean body mass and increase in body fat. The percentage of adolescents and young adults living with prediabetes was higher in males and participants with obesity (59). Within the global prevalence, there are 14 million more men than women (198 million men vs 184 million women) suffering from diabetes (59).

Diabetes and prediabetes have been studied in the UAE. The IDF atlas 2019 estimates age-adjusted prevalence rate of diabetes as 16.3% (CI 13.6 – 19.2) (67). The UAE National Survey Report 2017-2018, published by the Ministry of Health,

estimated that the prevalence of diabetes in UAE was 11.8%, and the prevalence among Emirati citizens was 10% (11). Prediabetes was estimated as 11.7% in the whole population, 9.7% among Emiratis. Another recent report, published in November 2019, estimated the diabetes prevalence among Emiratis as 21.2% in males and 23.3% in females, while prediabetes accounted for 17.4% males and 16.7% females (68). In 2012, a national screening program, called Weqaya, estimated a prevalence of 27% for prediabetes and 18% for diabetes among nationals (17). The big difference in prevalence rates across the reports is probably due to the difference in selected populations and diagnostic markers.

3.1.3 Dyslipidemia

Dyslipidemia is the metabolic abnormality that contributes to a persistent increase in the plasmatic concentration of cholesterol and triglycerides (69). This condition can be grouped into three different types which are hypercholesterolemia, hypertriglyceridemia, and mixed hyperlipidemia all elicited as a consequence of the elevation of cholesterol and triglycerides compounds. According to Cappi et al. (70) the condition is a common cause of morbidity globally with the most popular type being the hypercholesterolemia which is identified as having an overall cholesterol level of above 5.0 mmol/L or 190 mg/L. The WHO further note that hypercholesterolemia contributes to approximately 2.6 million (4.5%) global deaths with 39% of the affected being males and 40% females (71).

Dyslipidemia which is inclusive definition of elevated cholesterol, which is a lipophilic molecule that is crucial for the body. Cholesterol travels in the blood stream in lipoprotein molecules: low-density lipoprotein cholesterol (LDL-C) and low high-density lipoprotein cholesterol (HDL-C). Total cholesterol, LDL-C, HDL-C and triglycerides represent the lipid profile in the body which constitutes as significant

modifiable risk factor for NCDs. Dyslipidemia related NCDs had been estimated to contribute to 65% of the overall deaths with 30% of these deaths being as a consequence of cardiovascular diseases based on the WHO reports (8). According to Baghbani-Oskouei et al. (72) the majority of NCDs that are elicited by dyslipidemia include hypertension, type 2 diabetes and mortality rates globally. Also, dyslipidemia is identified as a significant contributor in the development of the coronary heart disease with Peng et al. noting it as cerebrovascular outcomes, while Willey et al. observed that it is evidenced by the correlation between lipid levels and cardiovascular diseases (73, 74). This is evidenced by WHO report that has noted that 39% of the coronary, hypertension, type 2 diabetes and cardiovascular diseases are as a consequence of the increased prevalence of dyslipidemia (8).

Successful prevention and treatment of dyslipidemia condition ought to be perceived as a critical segment in the individual cardiovascular prevention interventions which should be addressed primarily to those with higher risks. According to Zodda et al. (75) the prevention is nevertheless dependent on the clinical characteristics of an individual (hypertension and diabetes) and other risk factors (familiarity, habitual smoking and sedentary lifestyle).

The effect of age and gender differences in the prevalence of dyslipidemia is evident and unique based on the sociodemographic characteristics of an individual. For instance, the WHO noted that the global prevalence in 2008 was 37% for the men and 40% for women (76). In terms of age, the study pointed out that the prevalence increased by age with the peak prevalence being after age 60 and significantly prevalent in men under 50 years old than in women. Conversely, Hendrix et al. (77) study that comprised of wide-array respondents from different sociodemographic characteristics noted that 65% of dyslipidemia hypertensives were men and 35% being

women. The study equally noted that majority of the affected patients are aged 64 years which is an average number of population of dyslipidemia hypertensives. These findings are in line with Li et al. (78) study that found out that 43.3% of individuals suffering from the condition were men with 38.7% being women.

Currently, dyslipidemia is identified as a critical modifiable risk factor for cardiovascular disease and the leading cause of mortality in UAE (79). Findings of Al Sifri et al. (80) study that involved multiple respondents from UAE showed that 85.7% of all patients suffered from dyslipidemia. These findings were affirmed by Radaideh et al. (81) study that focused on 74% of 495 patients suffering from dyslipidemia. The study found that out of these patients, half of them had hypertension (43%) with one-third having diabetes (32.4%). According to the Ministry of Health's report and Weqaya, 44% of the population has dyslipidemia (11, 17).

3.1.4 Hypertension

Globally, approximately 7.5 million deaths or 12.8% of the overall annual deaths are attributed to high blood pressure (82). The WHO projected that by 2025 the cases of high blood pressure would increase to 1.56 billion adults. Furthermore, according to the definition by Joint National Committee 8, normal blood pressure is a systolic blood pressure <120 mm/Hg and diastolic blood pressure <80 mm Hg (83). A high blood pressure – or hypertension- can be identified as a systolic blood pressure level of ≥140 mm/Hg of a diastolic BP level ≥ 90 mm/Hg.

The pathology of hypertension is not clearly understood but identified as a silent killer with minimal symptoms being reported in early stages to the point of occurrence of severe medical crisis such as heart attack, stroke or chronic kidney disease (83). Due to lack of awareness on the pathology of hypertension, it is only through diagnosis that detection can be done. This is affirmed by Ingale and Dixit who

noted that despite a majority of patients suffering from HBP being asymptomatic, the patients report suffering from headaches, lightheadedness, vertigo, altered vision and fainting episodes (84).

From a global perspective, Erem et al. (85) pointed out that hypertension is a critical public health issue and is considered as a modifiable risk factor for cardiovascular complications, cerebrovascular disease, and end-stage renal diseases which are all grouped as NCDs. To sustain this, You et al. (86) described hypertension as the second largest risk factor leading to disability and death and third leading risk factor of the total burden of diseases. Additionally, Singh et al. (84) study that evaluated the prevalence and associated risk factors of hypertension noted that apart from the coronary heart diseases, it is linked to 70% of the occurrence of heart failure, peripheral vascular disease, renal impairment, retinal haemorrhage and visual impairment.

Despite hypertension being prevalent among all people of different ages, it is directly linked with mortality in the middle and old age (87). In terms of gender, men have a higher prevalence compared to women, unless the women are menopausal (88). A study conducted between 1999 to 2004 noted that women had a higher blood pressure due to high cardiovascular risk factors than men including central obesity and elevated BMI (89). Also, Blumenthal et al. (89) noted that women had higher systolic blood pressure as opposed to men with >80% of them being postmenopausal. In regard to obesity, Ong et al. (90) noted that more than 79% of women who have obesity are likely to suffer from high blood pressure as opposed to men.

In UAE, the National Epidemiological Study of Hypertension in the UAE (NESH-UAE) has pointed out that hypertension is higher among the Emiratis aged 30 to 50 years with prevalence being higher in females (54%) as opposed to males (47%)

(91). This is affirmed by a more recent study by Abdulle et al. (92) that has evidenced on existence of a high prevalence of hypertension among UAE children and adolescents with the prevalence being 34.8% for the females and 34.0% for males. The NCDs prevalence in UAE as noted by Razzak et al. (93) is a significant issue among the UAE. According to the study, 5% of all the NCDs are a consequence of the hypertension with the other risk factors being cholesterol and obesity. In terms of mortality rates, it was noted that a quarter of Dubai Emirati population has in past been diagnosed with hypertension which contribute to the development of cardiovascular morbidity and mortality in long term (94). Also, Al-Shamsi et al. (95) pointed out that the prevalence of chronic kidney diseases and cardiovascular diseases among UAE nationals has increased by 4.6% in males and 2.8% in females within 9 years, with a majority of the patients having the hypertension. According to the UAE National Health survey (2019), hypertension prevalence is 28.8% in 18-40 age group (11).

3.1.5 Central Obesity

In the year 1997, expert consultants on obesity at WHO recognized the medical significance of abdominal fat mass that is commonly referred to as central obesity, visceral obesity, or abdominal obesity (96). According to Straznicky, Lambert, Lambert and Esler (97) central obesity is the result of concentration of Non-Esterified Fatty Acid (NEFA) that damages glucose disposal that is insulin related. Central obesity is defined as accumulation of fat in the abdominal area and is measured by waist circumference, waist-to-stature ratio, and waist-to-hip ratio (98). Worldwide prevalence of general as well as abdominal or central obesity is increasing rapidly.

Central obesity has been found to be strongly associated with cardiovascular diseases (99-101). A study conducted by Sahakyan et al. (102) among the adult population with 15,184 individuals between the ages of 18 to 90 years revealed that a

person having normal weight but a central obesity has less chances of long-term survival. Casanueva et al. (100) stated that the frequency of cardiovascular disease increases with abdominal adiposity. These studies also indicated that the associated factors of obesity like diabetes mellitus, hypertension, increase the chances of cardiovascular diseases among individuals.

It was noted that age has significant impact on central obesity (103). Central obesity was found to increase with age. Moreover, a study conducted by Stevens, Katz and Huxley (104) revealed that waist-to-hip ratio which is one of the significant measures of abdominal obesity increases with age. However, abdominal obesity has also been observed among young adults (105). In addition, studies have also shown gender as one of the differentiators in central obesity (106, 107). It was revealed that central obesity has significantly increased among men than women (108). The study noted that this might be because of better metabolic profile of women than men and thus fat accumulation becomes less.

Central obesity is not studied frequently like other cardiometabolic risk factors in the UAE. Hajat et al. (17) estimated central obesity to be 55% in 2012. Sulaiman et al. (56) compared central obesity in diabetic and non-diabetic UAE nationals and reported a prevalence of 63% vs 46%, respectively. Al Dhaheri et al.'s (38) study on metabolic syndrome among young university students (17-25 years) estimated a prevalence of 18.2% for central obesity. Other multiethnic studies reported by Yusufali et al. and Malik et al. reported different rates of 43.4% and 24%, respectively (13, 109). All rates mentioned were derived from different cities, populations and approaches.

3.2 Other risk factors associated with cardiovascular diseases

3.2.1 Social Factors and family history of NCD

Social factors include the sociodemographic or socioeconomic factors, that include education, employment and marital status. In this study, family history of NCDs is considered as a social factor as well.

Socioeconomic status (SES) is not specifically confined to a country's status and income. Instead, it refers to a person's social position in a society. Health improvements do come with a country's economic prosperity and it can be translated in reductions in morbidity and mortality. However, there are substantial inequalities related to SES (110). The relationship between SES and health is irrespective of a country's wealth, due to the Income Inequality Hypothesis.

An individual's health is influenced by material factors like poverty, unemployment and poor housing and psychosocial factors like stress and depression (111). These determinants affect individuals from childhood and continue through life. This leads to the theory that with a lower personal SES, the worse the health is likely to be (112).

Indicators of SES on an individual's level can be in relation to education, occupation, household crowding, materials ownership, parity, marital status, neighborhood and the list goes on. The cultural specificity of indicators is challenging in research; for instance, an indicator can be valid in one country but not the other. For example, in a high-income country, a car ownership is not an indicator of wealth if everyone owns a car. In high-income countries, low SES among adults is associated with high risk of CVD in men and women (113). It was reported that the risk increased by 55% in men and by 2-folds in women.

There are a number of studies that have highlighted the importance of social factors such as education and occupation and their relationship with metabolic syndrome (110, 114). Although the cause and effect relationship between education and cardiovascular risk factors are complex, studies have shown that the higher the education level of the individuals is, the greater is the chance of adequate nutrition (115). With proper education, individuals are more aware of good nutritional habits and are less likely to have injurious health habits like smoking or alcohol consumption that reduces the chances of hypertension, diabetes, and obesity (116, 117). Work-related factors have different effects on health. For instance, having an income can increase health quality by being able to healthy foods, but the stress and demands on a job can cause negative health effects. Job stress increased CVD risk by 50% (118).

Marital status is one of the social determinants that has an influence on health. A meta-analysis on the effect of marital status on cardiovascular disease was led by Wong et al. included 34 studies with more than 2 million pooled participants (119). The study concluded that compared to married individuals, being unmarried (never married, divorced or widowed) increased the odds of CVD by 42% and coronary heart disease (CHD) by 16%. It also affected the prognosis after CVD, where being unmarried increased the odds of CHD-death and stroke-death by 43% and 55%, respectively. On the other hand, other studies showed that marital status has been reported to be associated with the early stages and progression of cardiovascular disease, an association that may stem partially from the effect of marital quality on metabolic factors. In a study that measured the effect of marriage quality on metabolic disease showed that women in high-quality marriages are at lower risk of developing metabolic syndrome (120).

There has been limited research in the context of the UAE and the socio-economic factors that causes cardiovascular diseases. One patient-based study done in hospitals of UAE and Saudi Arabia concluded that patients from rural centers were more likely to have diabetes, hypertension, dyslipidemia, coronary artery disease and percutaneous coronary intervention (121). After adjustment for confounders, it was concluded that CHD increased by 2.4 folds for people living in rural areas. Higher income was also associated with an increased CHD risk by 7-folds. Unemployment was associated with a 2.21-fold increase in CHD risk. Khafaji et al. (122) evaluated the marital status and patient outcome in patients with acute coronary syndrome in the UAE. It was reported that widowed patients were more likely to have diabetes and hypertension, but less likely to be smokers.

The family history of the cardiovascular diseases influences the risks of metabolic diseases based on the number and age of first-degree relatives affected. Family history identifies the medical and health information of people in a similar lineage. The World Heart Federation (WHF) states that if a first-degree relative suffered from a heart attack before the age of 55 for men, or 65 for women, the subject is at greater risk of developing the disease (123). If both parents suffered heart disease, this could increase the risk by 50%. Research studies established a genetic contributor for hypertension, dyslipidemia, and hyperglycemia. According to Kolber and Scrimshaw, the siblings of patients with cardiovascular diseases have a 40% risk increase (124). The study also noted that offspring of parents with premature cardiovascular diseases have 60% to 75% increase in the risks.

A study conducted on the Framingham cohort concluded that offspring of parents with cardiovascular disease had a 60-75% increase in relative risk for suffering of cardiovascular disease (124). This means that family history is an independent risk

factor for cardiovascular diseases. This informs on its applicability as a tool for screening in identifying individuals particularly the asymptomatic young adults with increased risks of cardiovascular diseases. The relevance of identifying the family history of metabolic diseases has been known to influence people's lifestyle changes, enhancing individual empowerment and influencing clinical intervention (125). The awareness of the family history of cardiovascular diseases should not be sufficient determinant in altering individual health-related behaviors (126). There is a need for future studies to focus on explaining the process in which family history of cardiovascular diseases or perceived cardiovascular risk can be utilized in informing a change in health-related behavior changes.

In UAE, limited research has evidently studied the family history of metabolic diseases and how this influences cardiovascular diseases. One study that was designed to explore awareness in Emirati women addressed that 63% of women in their sample were of that family history plays a role in heart disease (127). Another study touched upon family history and diabetes; it showed that having a family history of diabetes significantly increased the prevalence for diabetes in subjects in certain ethnicities (68).

3.2.2 Smoking

According to the WHO, smoking and the use of tobacco are one of the major causes of cardiovascular disease (128). Tobacco kills 50% of its users, and is responsible for 8 million deaths each year. Eighty percent of smokers live in low- and middle-income countries. A collaborating report by the WHO and World Heart Federation stated that 10% of all the deaths related to cardiovascular disease are related to tobacco consumption (129). The report also revealed that a lack of awareness about the harmful effect of tobacco consumption is increasingly causing risks to

cardiovascular diseases and resulting in an increasing number of deaths. More recently a study conducted by UK Biobank among 472,000 participants noted that smoking is one of the significant causes for cardiovascular diseases (130). In particular, the study noted that people smoking 20 or more cigarettes every day are more prone to heart attacks. However, in contrast to the study conducted by UK Biobank, National Health Services (NHS) noted even one cigarette a day increases the chances of stroke or other kinds of heart diseases by 40% (131). In addition, the study reported that smoking one cigarette a day increases risks for heart diseases by 48% among the males and 57% among the females. Thus, women smokers were found to be more prone to having heart disease than men.

Furthermore, the Centre for Disease Control and Prevention (CDC) noted how smoking exposes individuals to toxic substances and makes them more susceptible to cardiovascular diseases (132). It was noted that the chemicals contained in the cigarettes causes swell and inflammation in the cells along the line of the blood vessels that narrows down the vessels causing respiratory problems and cardiovascular conditions. Atherosclerosis, Peripheral Arterial Disease (PAD), heart attacks or stroke, Coronary Heart Disease are some of the common cardiovascular conditions caused due to smoking. The NHS also noted that smoking is one of the significant risk factors that cause Coronary Heart Disease (133). The carbon monoxide and nicotine that emits from cigarette smoking causes strain in the heart causing faster heartbeat. These toxic substances also increase the risk of blood coagulation. According to NHS smoking cigarettes increases the chance of heart disease by nearly 24% by damaging coronary arteries. Recently a study conducted by Banks et al. (134) noted that tobacco is one of the leading risk factors for cardiovascular diseases and heart failure. It also found an association of Paroxysmal tachycardia or irregular heartbeat.

According to the WHO, cardiovascular diseases are one of the major causes of death in the UAE and tobacco use has been identified as one of the major causes (6). The data published by WHO also predicted a rising trend of tobacco smoking among men till 2025. The World Tobacco Atlas, that analyzes the use of tobacco and its consequences, revealed that 27 deaths that are happening weekly in the UAE are associated with tobacco consumption and its related diseases (135). The atlas reported that 21.6% of male adults (above 15 years) are smokers, and only 1.9% of women are smokers. The 2018 National Healthy Survey reported that 15.7% in males and 2.4% in women are smokers. In the pilot study of the UAE Healthy Future Study cohort, smoking prevalence was reported to be 36% in men and 3% in women (136). After cotinine testing, it was verified rates were 42% in men and 9% in women. Dual and poly-smoking of different types of tobacco (Cigarettes, Shisha, or Midwakh) were also common.

3.2.3 Physical inactivity

Physical inactivity is an important risk factor in developing CVDs (137). Physical activities elicit positive implications on metabolic control measured by HbA1c, blood glucose, or insulin sensitivity all linked to cardiovascular diseases (138), and regular exercises positively improve cardio-respiratory fitness, muscular strength, and endurance, body mass and fat composition. Physical activity plays important active and passive roles in the prevention of coronary artery disease. Epidemiological studies observed a dose-response relationship where the risk for cardiovascular events reduced by 20% (139). Exercise was shown to improve endothelial function, slow the progression of cardiovascular stenosis and myocardial perfusion. Additionally, sedentary behavior is considered an important risk factor for CVD, independent of physical activity levels (140).

In the Middle East, a study by Gehani(141), evaluating the risk factors of myocardial infarction, physical inactivity was cited as one of the 9 major causative factors of heart disease mortality. The study summarized that cardiovascular risk factors have a prevalence inversely linked to physical activity levels. Such findings informed the American College of Sports Medicine (ACSM), Centers for Disease Control and Prevention (CDC) and other professional and health organization to develop position statements (142). These statements offer recommendations for physical activities aimed at improving health outcomes. According to Smith et al. (143), these recommendations span past aerobic activity benefits and other physical activity components such as strength training and flexibility.

A study by Razzak et al. (93) that focused on evaluating the prevalence and risk factors of cardiovascular disease in UAE provided relevant findings. In a study conducted in Dubai, 37.3% of the patients with cardiovascular diseases were physically inactive (13). Increase physical activities in youth and young adults was recommended in study of university students in UAE (144). There is a need to establish interventions for promoting lifestyle changes by adolescents and to enhance their physical activities (145). Loney et al. (9) study based in UAE recommended aspects of surveillance and monitoring, research, training and federal legislation to focus on areas of physical activities. In a more detailed approach, in the context of UAE, there is a need for strategies to be put in place for establishing a national public health program (146). There however exists a research gap in UAE as there is no study that has directly focused on the evaluation of the relationship between the inactivity and cardiovascular complications.

Chapter 4: Methods

4.1 Study Population

The study sample is retrieved from the UAE Healthy Future Study (UAEHFS) (147). This study is designed as a prospective cohort study that is recruiting UAE national volunteers from the general population aged 18 – 40. The target size is 20,000 nationals to be followed-up for years ahead to examine the association between multiple exposures, including environmental, lifestyle, and genetic risk factors, to non-communicable diseases. Participants recruitment is based on convenience sampling where volunteers are invited to participate in the study. Until December 2018, recruitment took place across 7 clinical research centers located in Abu Dhabi and Al Ain; Zayed Military Primary Healthcare Center, Abu Dhabi Blood Bank, Al Nahyan Military Camp, Healthpoint Hospital, Cleveland Clinic Abu Dhabi, United Arab Emirates University (UAEU), and Al Ain Blood Bank.

This project was based on the cross-sectional analysis of baseline data from 5,167 participants of the UAEHFS cohort, recruited between February 2016 and December 2018. Subjects were Emirati nationals aged 18 up to 40 years. All participants are required to give an informed consent. Only participants that suffer any acute infection at the time of recruitment and women that are pregnant are excluded from the study.

The UAEHFS is conducted in accordance with the principals of the Declaration of Helsinki and in conformity with the ICH Guidelines for Good Clinical Practice (CPMP/ICH/135/95) July 1996. The informed consent and all data collection means were approved by the Research Ethics Committees (REC)/ Institutional Review Boards (IRB), reference number 0072017R. For confidential sensitive data, the participants were assigned a unique research number. Questionnaire responses, physical measures and lab results were maintained under the unique research number,

at the NYUAD data management center. No individual identifiable information was included in this research.

4.2 Data Collection

At baseline, participants answered a questionnaire, underwent physical measurements and gave biological samples. The self-completed electronic questionnaire collected information on risk factors that pertain to NCD development. The questions explored socio-demographic factors, general health, physical activity, tobacco use, early life exposures and family history. A copy of the detailed questionnaire is in appendix 1. The subsequent steps of physical assessments included measuring blood pressure, anthropometric measures and body composition. The final step was to give 8 ml of venous blood.

4.2.1 Social factors

Socio-demographic elements like sex, age, employment status, marital status, and educational accomplishment were collected through the electronic questionnaire. Employment status was then summarized as employed, unemployed or current student. Marital status captured whether a person is single, married, widowed or divorced. Latest educational attainment had a range of answers from uneducated, elementary, primary, secondary to undergraduate and graduate degrees. The answers were later categorized to two; high school and below or college and above.

Of the unmodifiable risk factors, family history of NCDs was the only element that was captured at the time. Multiple questions were designed to collect the maternal and paternal health history. The parental diseases were heart disease, stroke, diabetes, obesity, and high cholesterol. Therefore, the family history was categorized as having

family history (if one or more of the diseases or risk factors) and no family history of chronic disease

4.2.2 Behavioral factors

Lifestyle or Behavioral factors such as smoking and physical activity were assessed through the questionnaire. Different smoking methods like cigarette smoking, traditional pipe (midwakh) and water pipe (shisha) were covered.

Physical activity intensity and frequency questions are adopted from the WHO's Global Physical Activity Questionnaire (GPAQ) (148). This is a validated tool that covers several components of physical activity, such as intensity, duration and frequency. The GPAQ collected physical activity information across 3 domains: activity at work, travel to and from places, and recreational activities. The GPAQ output was used to calculate the metabolic equivalents (METs) to further indicate whether a person's physical activity is categorized as high, moderate or low.

4.2.3 Physical measurements

Weight and height were measured by a clinical research nurse. Height was measured using a stadiometer (Seca, Germany). Participants were asked to put their back against the vertical scale, keep feet parallel to each other, toes pointing forward and soles flat on the platform. All four contact points (back of the head, shoulder blades, buttocks, and heels) made contact with the backboard. The participant's head is gently, aligned in the Frankfort Plane, so that they are looking straight forward with their ear holes in same horizontal plane as the lower border of their eye sockets. The height is read in centimeters at the end of inhalation; the participant is asked to take a deep breath in and hold this position during measurement.

Weight was measured by using the Tanita MC-780 MA body composition analyzer (Tanita Inc, Tokyo, Japan). The device works by passing an imperceptible current through the body, via the arms and legs and the results are recorded electronically. Participants with a pacemaker or an electrical medical implant were excluded from standing on the device. Body mass index (BMI) was automatically calculated, via the Tanita, by dividing weight by height in meters squared (kg/m^2).

Waist and hip circumferences are measured by the SECA standardized measuring tape following the WHO STEPwise Approach to Surveillance (STEPS) protocol (149). Waist circumference was measured approximately at midpoint of the lower margin of the last palpable rib and the top of the iliac crest and recorded to the nearest centimeter. Hip circumference was measurement at the widest portion of the buttocks and similarly recorded to the nearest centimeter.

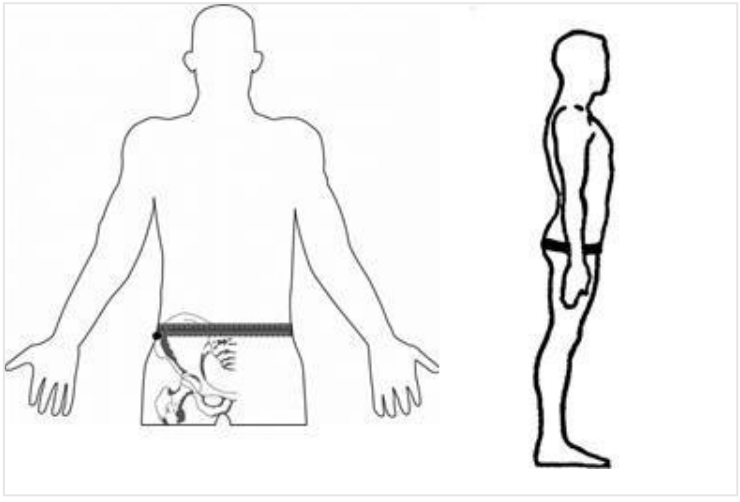


Figure 7: Waist and hip circumferences

Blood pressure was measured by SphygmoCor Xcel device (Atcor medical, New South Wales, Australia), which electronically measures brachial systolic and diastolic pressures. Brachial blood pressure if measured from the left arm. The right arm is only used if the left is not practical e.g. amputee. It is taken twice or 3 times, with a minute break in between, then the average is taken.

4.2.4 Blood samples

Blood samples were collected by venipuncture using a 21-gauge butterfly needle taped to the skin. Plasma was collected in EDTA Vacutainers (8ml) from Becton Dickinson. Random and fasting blood was collected into SST tube that is centrifuged at 3000 – 3500 RPM for 10 minutes. The sample was then stored at 4°C and transported to the lab, then analyzed using UniCel DxC 600 System. The lipid panel included total cholesterol, LDL and HDL levels, and triglycerides. Analysis of HbA1C and glucose was done using UniCel® DxC 600 System.

4.3 Cardiometabolic risk factors definition criteria

4.3.1 Obesity

According to the WHO definitions, a BMI of less than 25 kg/m^2 is considered normal, and a BMI that lies between 25 and 30 kg/m^2 is considered overweight (150). An individual whose BMI lies above 30 kg/m^2 is considered obese.

4.3.2 Dysglycemia

Diabetes was defined as self-reporting diabetes or insulin use in the questionnaire, a test of HbA1c of ≥ 6.5%, or glucose ≥ 126 mg/dL for fasting samples (151, 152). Prediabetes was defined as having HbA1c level between 5.7% and 6.5% or fasting glucose between 100 and 126 mg/dL (152). Both diabetes and prediabetes cases were categorized as abnormal glycemic status, or “dysglycemia”.

4.3.3 Dyslipidemia

Dyslipidemia is defined as either self-reported history of abnormal cholesterol level, or taking a lipid-controlling medication or having an abnormal level of any of the following; LDL cholesterol level of ≥ 130 mg/dL, HDL cholesterol level of ≤ 40

mg/dL for men or ≤ 50 mg/dL for women, Total Cholesterol ≥200 mg/dL or Triglycerides ≥ 150 mg/dL for fasting samples and ≥ 175 mg/dL for random samples (153, 154) .

4.3.4 Hypertension

Elevated blood pressure, or hypertension, is defined as having a blood pressure reading of above 140/90 according to the American Heart Association guidelines (155). Hypertension is also defined as having self-reported "hypertensive" on the questionnaire and/or whether they are taking blood pressure-controlling medication.

4.3.5 Central obesity

Central obesity is indicated if the waist to hip ratio is equal to or greater than 0.85 for women and equal to or greater than 0.9 for men (96). A summary of the data collection methods is summarized in Table 1.

Table 1: Summary of data collection methods

Method of collection	Variable
- **Self-reported questionnaire**	- Sociodemographic data - Health data - Smoking - Physical activity - Family history
- **Physical Measurements**	- Blood pressure - Anthropometric measurements (height, weight, waist and hip circumferences)
- **Blood sample**	- HbA1c - Glucose - Lipid panel

4.4 Sample size

The power of a study refers to its ability to demonstrate an association if one exists. An a priori power analysis was used to determine the necessary total sample

$$n = \frac{Z^2 P (1 - P)}{d^2}$$

size given a desired α level, a desired power level (1-β) and an anticipated prevalence to be detected with desired precision. The calculations were performed using the formula:

Where *n* is the sample size, *Z* is the Z statistic for a level of confidence, *P* is the expected prevalence or proportion, and *d* is precision. The sample size (n= 384) was calculated based on the possibility to detect a prevalence of 50% with a precision (d)=0.05, power=0.8, and confidence level=0.95. The total available sample size (n=5,126) is sufficient to detect a 50% prevalence with 80% power, and 5% significance level for more than 10 strata or subgroups (gender by five age groups).

4.5 Statistical Analyses

Baseline characteristics of the study participants were presented overall, and by gender, BMI categories, and cardiometabolic risk factors groups. Categorical data was presented as frequencies and percentages and continuous variables were presented as means ± standard deviation. The frequencies and percentages were tested for significance of any differences in distribution between two or more groups using chi-square and Fisher's exact tests. For continuous variables, differences in means were measured by t-tests and one-way ANOVA tests for normally distributed data. Missing data were not replaced.

Age-adjusted prevalence rates were estimated using logistic models and presented with their 95% confidence intervals (CI). The age-adjusted rates were estimated for the overall prevalence of each CRFs and for the prevalence of different sociodemographic and lifestyle risk factors within each cardiometabolic risk factor. The crude and age-adjusted prevalence rates were also estimated for cardiometabolic risk factors by BMI categories. For age-standardization, population age values from

the Statistics Center Abu Dhabi (2018) were used to derive age-standardized prevalence rates (2).

The burden of CRFs was defined and estimated as number of risk factors per individual. The maximum number of risk factors was five per individual. Cardiometabolic risk factors were then grouped to form two burden groups; "0-1" and "≥ 2" risk factors. Characteristics of these groups were presented and examined for differences by age and gender. The burden groups were also displayed in graphic representations. To investigate the burden of CRFs by BMI categories, the cardiometabolic risk factors excluding obesity were then grouped to form "0-1" and "≥ 2" risk factors burden groups. Characteristics of these groups were also presented and examined for differences by age, gender, and BMI categories (normal, overweight, and obese).

Associations between the different sociodemographic and lifestyle risk factors (exposures) and the individual and grouped cardiometabolic risk factors (outcome) were evaluated using univariate and multivariate logistic regression analyses. Age, gender, social and behavioral factors were all adjusted for in the multivariate models. For example, for estimating the independent association of a social factor with obesity as an outcome, the multivariate model will include as covariates other cardiometabolic risk factors in the model with the exposure variable; dysglycemia, dyslipidemia, hypertension and central obesity, along with age, gender and other social and behavioral factors. This was repeated for each cardiometabolic risk factor and the burden of CRFs as dependent variables. The associations were also evaluated stratifying by gender and BMI categories. Crude and adjusted Odds Ratios (OR) with their 95% CIs were reported.

The analyses were performed using Stata 15 software (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). The significance level of the statistical tests was set at 5%.

Chapter 5: Results

5.1 Objective 1: Describe the distribution of cardiometabolic risk factors in this population

Overall, 5,167 subjects aged between of 18 to 40 years were recruited from February 2016 to December 2018 and had relevant data. Participants were all Emiratis coming from different cities; with the majority (around 70%) from Abu Dhabi Emirate. Complete self-reported data was available for up to 85% of the participants, depending on data point concerned. Complete body measurements including anthropometrics and blood pressure was available for 94% of the sample. Finally, complete blood sample testing was available for 98% of the sample.

Table 2 summarizes the population's social and behavioral characteristics. The study sample included 38% females and 62% males. The mean age for the population was 25.7 years with a median age of 24 years. The age distribution was significantly different between women and men. Women were generally younger in the sample, with a mean age of 24.5 years, median age 22, while men had a mean age of 26.4 years, with a median age of 25. The majority of participants were below 25 years old (Figure 9). The social factors included sociodemographic characteristics and family history of NCDs. The sociodemographic characteristics of the population were described based on three determinants; marital status, employment status and latest education degree attainment. Most of the participants were single (64%) and employed (54%). Half of the participants had college or post-graduate degree while the other half had a high-school diploma or below. Among females, 75% were single and most of them were students while 56% of men were single and 68% employed. Family history of NCDs was reported by 56% of the overall population.

Table 2: Social and behavioral characteristics of the participants population.

	OVERALL **N= 5,167**	**MEN** **3,202 (62%)**	**WOMEN** **1,965 (38%)**	**P-value**
Age (years), mean (SD)	25.7 (6.2)	26.4 (5.9)	24.5 (6.3)	0.00
18-<20	872 (16.9%)	374 (11.7%)	498 (25.3%)	
20-<25	1,824 (35.3%)	1,091 (34.1%)	733 (37.3%)	
25-<30	1,068 (20.7%)	778 (24.3%)	290 (14.8%)	
30-<35	784 (15.2%)	563 (17.6%)	221 (11.3%)	
35-40	619 (12%)	396 (12.4%)	223 (11.4%)	
Marital status				0.00
N	4,409	2,709	1,700	
Single	2,804 (63.6%)	1,522 (56.2%)	1,282 (75.4%)	
Married	1,497 (34%)	1,144 (42.2%)	353 (20.8%)	
Divorced/widowed	108 (2.5%)	43 (1.6%)	65 (3.8%)	
Employment				0.00
N	3,668	2,240	1,428	
Employed	1,978 (53.9%)	1,535 (68.5%)	443 (31%)	
Students	1,032 (28.1%)	399 (17.8%)	633 (44.3%)	
Unemployed	658 (17.9%)	306 (13.7%)	352 (24.7%)	
Education level				0.032
N	4,310	2,657	1,653	
≤ high school	2,326 (54%)	1,468 (55.3%)	858 (51.9%)	
≥ college	1,984 (46%)	1,189 (44.8%)	795 (48.1)	
Family history of NCD				0.00
N	5,058	3,136	1,922	
No	2,228 (44.1%)	1,459 (46.5%)	769 (40%)	
Yes	2,830 (56%)	1,677 (53.5%)	1,153 (60%)	
Smoking				
N	3,927	2,389	1,538	
Non-smoker:	2,628 (66.9%)	1,170 (49%)	1,458 (94.8%)	0.00
Current smoker:	1,299 (33.1%)	1,219 (51%)	80 (5.2%)	
Cigarette	666 (17.7%)	643 (28.5%)	23 (1.5%)	
Midwakh	802 (21.2%)	779 (34.3%)	23 (1.5%)	
Shisha	791 (21.2%)	722 (32.3%)	69 (4.6%)	
Physical activity				
N	2,341	1,393	948	
Metabolic Equivalent (minutes/week), mean (SD)	5514.3 (6306.8)	6456.4 (7003.2)	4129.9 (4792.4)	0.00
Low	1,894 (80.9%)	1,119 (80.3%)	775 (81.8%)	0.00
Moderate	189 (8.1%)	95 (6.8%)	94 (9.9%)	
High	258 (11%)	179 (12.9%)	79 (8.3)	

Data is presented as mean values with standard deviation (SD) or frequency numbers (N) and percentages (%). P-values are derived from t-tests and chi-square tests.

Smoking is reported in 33% of the population. Of which, 17% were smoking cigarettes, 21% smoking midwakh and 21% smoking shisha (water-pipe). Among women that smoked, smoking shisha was found more popular than smoking other

types of tobacco. Men smoked the 3 types almost similarly. The majority of smokers smoked a single type of tobacco, men tended to smoke multiple types more than women. For physical activity, around 81% were categorized as performing low-physical activity and 19% as moderate-to-high physical activity. A similar distribution was seen among men and women.

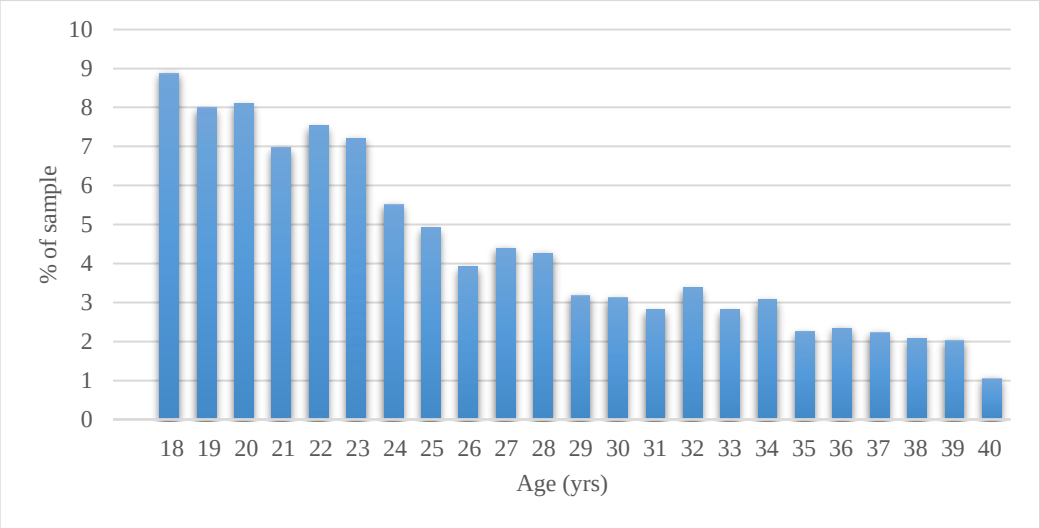


Figure 8: Age distribution of the participants

The cardiometabolic characteristics of the study sample are presented in Tables 3 and 4. The mean BMI in the sample was 26.9 kg/m^2, and it was lower in women than men. Two-thirds of the sample were either overweight (30.5%) or obese (27.2%). In women, the proportions were 23.6% for overweight and 22.6% for obesity. In men, they were 35% and 30.1% for overweight and obesity, respectively.

Table 3: Mean values of cardiometabolic markers of the participants

Cardiometabolic markers	Overall, Mean (SD)	Men, Mean (SD)	Women, Mean (SD)	P-value
Body Mass Index (BMI), Kg/m^2	26.9 (6.3)	27.7 (6.0)	25.8 (6.6)	0.00
Waist – hip ratio	0.82 (0.09)	0.87 (0.07)	0.77 (0.08)	0.00
Systolic blood pressure, mmHg	126 (14.1)	131.2 (13.1)	117.8 (11.6)	0.00
Diastolic blood pressure, mmHg	78 (77.7)	80.3 (10.2)	74.3 (8.6)	0.00
Low-density lipoprotein (LDL), mg/dL	115.9 (34.0)	122 (35.8)	105.9 (28.1)	0.00
High-density lipoprotein (HDL), mg/dL	48.4 (12.9)	43.9 (10.6)	55.7 (13.0)	0.00
Total cholesterol, mg/dL	182.5 (36.0)	185.8 (38.6)	177 (30.3)	0.00
Triglycerides (TG), mg/dL	103.9 (77.6)	118.8 (86.0)	79.3 (52.8)	0.00
Glycated hemoglobin (HbA1c), %	5.26 (0.66)	5.29 (0.71)	5.21 (0.58)	0.00
Fasting blood glucose (FBG), mg/dL	94.3 (25)	96.4 (25.7)	88.8 (22.3)	0.00
Data is presented as means (Standard deviation). P-values are derived from t-tests.				

Based on HbA1c analysis, 6.5% of the sample had prediabetes and 1.9% had diabetes. Fasting serum glucose yielded a rate of 17.8% for prediabetes and 2.7% for diabetes. Together; glycated hemoglobin, fasting blood glucose and self-reported diagnosis or medication identified prediabetes prevalence as 8.7% and diabetes as 3.9%. Men had a higher proportion of prediabetes (10.6% vs 5.7%) and diabetes (4.0% vs 3.6%) than women. The overall prevalence of dysglycemia was 12.4%. All lipid levels were significantly higher in men than women, with the exception of HDL (Table 4). Dyslipidemia was reported in 61.7% of the study sample, and it was higher in men than women. The mean systolic and diastolic blood pressures were significantly different between men and women. The overall prevalence of hypertension was observed in 22.9% of the sample; 31% in men and 9.9% in women. Twenty-four

percent of the population had central obesity. One-third of men had an increased waist-to-hip ratio, while only 13.9% of women had that condition.

Table 4: Cardiometabolic characteristics of the participants

	Overall, N (%)	**Men, N (%)**	**Women, N (%)**	**P-value**
OBESITY:				
N	4,872	2,955	1,917	
Normal	2,064 (42.4%)	1,033 (35%)	1,031 (53.8%)	0.00
Overweight	1,485 (30.5%)	1,033 (35%)	452 (23.6%)	0.00
Obese	1,323 (27.2%)	889 (30.1%)	434 (22.6%)	0.00
GLYCEMIC ROFILE				
Based on HbA1c				
N	5,078	3,156	1,922	
Pre-diabetes	332 (6.5%)	227 (7.2%)	105 (5.5%)	0.01
Diabetes	96 (1.9%)	68 (2.2%)	28 (1.5%)	0.01
Based on Fasting Glucose				
N	1,065	769	296	
Pre-diabetes	190 (17.8%)	164 (21.3%)	26 (8.8%)	0.00
Diabetes	29 (2.7%)	24 (3.1%)	5 (1.7%)	0.00
Self-reported Diabetes	145/3,878 (3.7%)	91/2,352 (3.9%)	54/1,526 (3.5%)	0.596
Use of insulin	60/158 (38%)	35/96 (36.5%)	25/62 (40.3%)	0.002
Pre-diabetes	449 (8.7%)	338 (10.6%)	111 (5.7%)	0.00
Diabetes	199 (3.9%)	128 (4.0%)	71 (3.6%)	0.00
Dysglycemia	648 (12.4%)	466 (14.6%)	182 (9.3%)	0.00
LIPID PROFILE				
N	5,078	3,155	1,923	
High LDL	1,802 (35.4%)	1,341 (42.5%)	461 (23.9%)	0.00
Low HDL	2,231 (43.8%)	1,436 (45.5%)	795 (41.2%)	0.003
High total cholesterol	1,723 (33.9%)	1,201 (38.0%)	522 (27.1%)	0.00
High TG	1,174 (23.1%)	889 (28.2%)	285 (14.8%)	0.00
Self-reported Dyslipidemia	592/3,802 (15.6%)	396/2,308 (17.2%)	196/1,494 (13.1%)	0.001
Self-reported use of lipid lowering medication	83/597 (13.9%)	62/15.6 (15.6%)	21/200 (10.5%)	0.088
Dyslipidemia	3,188 (61.7%)	2,127 (66.4%)	1,061 (54%)	0.00
BLOOD PRESSURE				
Hypertension based on measurement	937/4,838 (19.4%)	826/2,962 (27.9%)	111/1,876 (5.9%)	0.00
Self-reported hypertension	326/3,817 (8.5%)	234 /2,323 (10.1%)	92/1,494 (6.2%)	0.00
Self-reported use of medication	110/341 (32.3%)	77/239 (32.2%)	33/102 (32.4%)	0.98
Hypertension	1,108 (22.9%)	921 (31%)	187 (9.9%)	0.00
CENTRAL OBESITY				
N	4,818	2,938	1,880	
Central obesity	1,170 (24.3%)	909 (30.9%)	261 (13.9%)	0.00
Data is presented as frequency numbers and percentages (%).				

Table 5 summarizes the crude, age-adjusted, and age-standardized prevalence rates for the risk factors. Across all risk factors, males had a higher prevalence than females, and the difference was consistently significant. The prevalence for each of the five major cardiometabolic risk factors change significantly across age groups in men and women, as visualized in Figure 9. The age-adjusted distribution of the metabolic risk factors was assessed within the social and behavioral determinants in men and women as presented in Table 6.

Table 5: Crude, age-adjusted, and age-standardized prevalence rates of cardiometabolic risk factors in the participants

	TOTAL POPULATION		
	Crude	**Age-adjusted**	**Age-standardized***
Obesity	27.2 (25.9 – 28.4)	26.5 (25.2 – 27.7)	30.2 (28.9 - 31.7)
Dysglycemia	12.5 (11.7 – 13.5)	11.7 (10.8 – 12.7)	14.6 (13.5 – 15.7)
Dyslipidemia	61.7 (60.4 – 63.0)	62.7 (61.3 – 64.0)	66.3 (65.0 – 67.6)
Hypertension	22.9 (21.7 – 24.1)	22.4 (21.2 – 23.6)	25.0 (23.7 - 26.4)
Central obesity	24.3 (23.1 – 25.5)	22.5 (21.3 – 23.8)	29.0 (27.6 - 30.4)
	MEN		
	Crude	**Age-adjusted**	**Age-standardized***
Obesity	30.1 (28.5 - 31.8)	29.7 (28 – 31.4)	32.0 (30.3 - 33.8)
Dysglycemia	14.6 (13.4 – 15.8)	14.0 (12.7 – 15.2)	16.1 (14.8 – 17.5)
Dyslipidemia	66.4 (64.8 – 68.0)	68.0 (66.3 – 69.7)	70.0 (68.5 – 71.5)
Hypertension	31.0 (29.4 - 32.7)	30.9 (29.2 – 32.6)	32.1 (30.4 - 33.9)
Central obesity	30.9 (29.3 - 32.6)	29.6 (27.9 – 31.3)	34.8 (33.0 - 36.6)
	WOMEN		
	Crude	**Age-adjusted**	**Age-standardized***
Obesity	22.6 (20.8 - 24.6)	21.6 (19.7 – 23.5)	27.4 (25.1 - 29.8)
Dysglycemia	9.3 (8.1 – 10.6)	8.3 (7.0 – 9.6)	11.6 (10.0 – 13.5)
Dyslipidemia	54.0 (51.8 – 56.2)	54.2 (52.0 – 56.5)	58.7 (56.3 – 61.2)
Hypertension	9.9 (8.7 - 11.4)	9.2 (7.8 – 10.5)	12.1 (10.5 - 14.0)
Central obesity	13.9 (12.4 - 15.5)	12.5 (10.9 – 14.0)	17.9 (15.9 - 20.1)

Data is presented as prevalence % (confidence intervals)
*Age-standardized rates were estimated using the Abu Dhabi population consensus from Statistical Center Abu Dhabi.Detailed prevalence rates of prediabetes, diabetes, and each lipid marker are in Appendix 2.

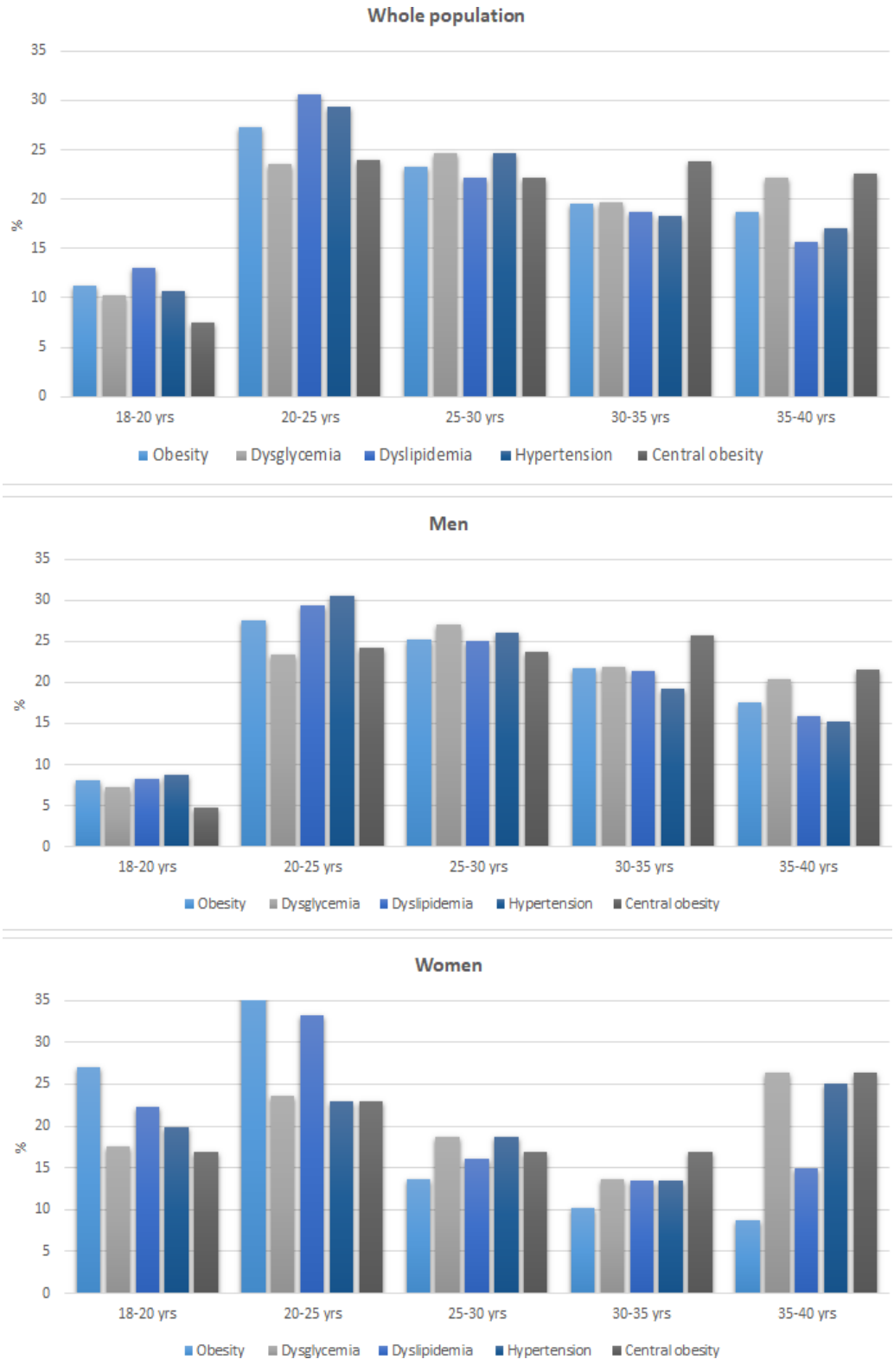


Figure 9: Cardiometabolic risk factors distribution across age groups.

Table 6: Age-adjusted prevalence (95% CI) of cardiometabolic risk factors by social and behavioral determinants.

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
MEN					
Marital Status					
Single/ divorced	**29.1 (26.4-31.8)**	**14.1 (12.1-16.1)**	**68.3 (65.5-71.2)**	33.8 (31-36.6)	**27.8 (25.1-30.5)**
Married	**29.7 (26.4-32.9)**	**15.8 (13.2-18.3)**	**67.5 (64-70.9)**	28.6 (25.4-31.8)	**30.8 (27.4-34.1)**
Employment Status					
Un-employed	**29.1 (23.5-34.6)**	**17.8 (13.1-17.7)**	**68.2 (62.8-73.6)**	**30.8 (25.5-36.1)**	**27.0 (22.0-32.1)**
Employed	**29.8 (27.3-32.4)**	**15.7 (13.7-17.7)**	**68.2 (65.7-70.7)**	**33.6 (31.1-36.0)**	**36 (33.6-38.5)**
Student	**31.8 (26.3-37.3)**	**9.4 (5.9-12.8)**	**69.8 (64.8-74.8)**	**26.2 (21.8-30.5)**	**18.6 (14.7-22.4)**
Education level					
≤ high school	**32.7 (30.2-35.2)**	15.7 (13.8-17.6)	**68.6 (66-71.2)**	33.7 (31.2-36.3)	30.6 (28-33.1)
≥ college	**25.1 (22.6-27.7)**	13.7(11.7-15.6)	**67.1 (64.3-70)**	28.6 (25.9-31.2)	27.8 (25.1-30.5)
Family history of NCDs					
No	**27.1 (24.7-29.6)**	**12.1(10.5-13.8)**	**65.7 (63.2-68.3)**	**25.7 (23.3-28.1)**	**29.3 (26.7-31.9)**
Yes	**31.8 (29.5-34.1)**	**15.6 (13.9-17.4)**	**69.7 (67.4-72)**	**35.1 (32.8-37.4)**	**29.8 (27.5-32.1)**
Smoking					
Non-smoking	**27.4 (24.7-30)**	15.1(13-17.2)	**63.6 (60.7-66.5)**	32.7 (30-35.5)	**26.4 (23.7-29.1)**
Smoking	**31.2 (28.5-33.9)**	14.4(12.4-16.4)	**71.1 (68.5-73.8)**	31(28.3-33.6)	**31.9 (29.2-34.7)**
Physical Activity					
Moderate/ high	25.2 (20-30.5)	11 (7.3-14.6)	66.8 (61-72.6)	33.1 (27.5-38.8)	22.9 (17.7-28)
Low PA	27.9 (25.2-30.6)	12 (10.1-14)	66.3 (63.4-69.2)	30.8 (28.1-33.6)	28.3 (25.5-31.1)

Data is presented as percentages (95% CI). Values in **bold font** have significant difference in proportions of cardiometabolic risk factors.

Table 6: Age-adjusted prevalence (95% CI) of cardiometabolic risk factors by social and behavioral determinants. (Continued)

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
WOMEN					
Marital Status					
Single/ divorced	**20.7 (18.5-23)**	**7.6 (6.1-9)**	**53.4 (50.6-56.2)**	**9.8 (8.1-11.4)**	**12.1 (10.2–13.9)**
Married	**22.3 (17.5-27)**	**10.4 (7.1-13.8)**	**60.6 (54.6-66.6)**	**9 (5.9-12.1)**	**12.6 (9-16.1)**
Employment Status					
Unemployed	**24.5 (19.8-29.1)**	**11.3 (8 – 14.7)**	**61.6 (56.4-66.8)**	**44.5 (8.1-15)**	**14.2 (10.5-17.9)**
Employed	**23.9 (19.2–28.5)**	**10.1 (6.9 – 13.3)**	**51.9 (46.3-57.6)**	**9.8 (6.6-12.9)**	**13.2 (9.6-16.8)**
Student	**17.7 (14-21.3)**	**4.8 (2.8 – 6.7)**	**53.6 (48.9-58.3)**	**10 (7-12.9)**	**10.6 (7.5-13.6)**
Education level					
≤ high school	**25.9 (22.7-29)**	9.4 (7.4 – 11.5)	59 (55.6-62.4)	10.5 (8.4-12.7)	14.3 (11.8-16.8)
≥ college	**15.8 (13.1-18.4)**	6.7 (4.9-8.4)	50 (46.4-53.7)	8.8 (6.8-10.9)	10.2 (8.1-12.3)
Family history of NCDs					
No	**18.2 (15.34-21)**	**6.6 (4.8-8.3)**	**50.3 (46.7-53.9)**	**7 (5.1-8.8)**	**11.3 (9 – 13.7)**
Yes	**24.2 (21.6–26.7)**	**9.4 (7.7-11.1)**	**57.2 (54.3-60.1)**	**10.9 (9 – 12.8)**	**13.2 (11.1-15.2)**
Smoking					
Non-smoking	**20.2 (18.1-22.4)**	7.6 (6.2-9)	54.2 (51.6-56.8)	9.5 (7.9-11.1)	11.3 (9.6-13)
Smoking	**28.9 (18.9-38.9)**	10.7 (4.3-17.2)	57.3 (46.3-68.3)	14 (6.5-21.5)	13.9 (6.6-21.2)
Physical Activity					
Moderate/ High	21.9 (15.5-28.3)	9 (4.7-13.4)	58.4 (50.9-65.8)	10.7 (5.9-15.5)	7.7 (3.7-11.8)
Low PA	19.3 (16.5-22.2)	6.5(4.7-8.3)	52.4 (48.8-55.9)	9.5 (7.4-11.7)	10.2 (7.9-12.4)

Data is presented as percentages (95% CI). Values in **bold font** have significant difference in proportions of cardiometabolic risk factors.

In men, obesity was found significantly higher in participants who were married, students, and smokers. Having an abnormal glycemic status was more significantly prominent in the married and unemployed groups. Moreover, dyslipidemia was higher in the unmarried, students, and with lower education. Hypertension and central obesity were significantly higher in the employed groups (Table 6).

In women, all cardiometabolic risk factors were higher in the married subjects, with the exception of hypertension, where it was slightly higher in the unmarried. Additionally, all risk factors were observed higher in the unemployed group. Only

obesity was found significantly higher in terms of higher education and smoking status. All cardiometabolic risk factors were higher in subjects with family history of metabolic abnormalities, compared with no family history.

Figures 10 and 11 present grid illustrations for comorbid statuses of having two cardiometabolic risk factors by gender and age groups, respectively. Among the people with dyslipidemia, more than 70% had a concurrent metabolic condition. The following condition was obesity, where 50% or more also had dyslipidemia or central obesity. However, among subjects with abnormal glycemic status, 25% and below had comorbidity with other risk factors. The patterns were similar in the whole sample, between sexes and across age groups.

Comorbidity in the whole population

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
Obesity % (CI)		51.7 (47.8 - 55.6)	35.1 (33.3 - 36.8)	47.4 (44.4 - 50.4)	54.9 (52 - 57.8)
Dysglycemia % (CI)	24 (21.8 - 26.4)		15.7 (14.5 - 17)	22.8 (20.5 - 25.4)	19.7 (17.6 - 22.1)
Dyslipidemia % (CI)	79.4 (77.2 - 81.5)	77.3 (73.9 - 80.4)		75.2 (72.6 - 77.6)	79.1 (76.6 - 81.4)
Hypertension % (CI)	39.4 (36.8 - 42.1)	40.8 (37 - 44.7)	27.8 (26.3 - 29.5)		36.6 (33.8 - 39.4)
Central obesity % (CI)	48.9 (46.2 - 51.6)	37.9 (34.1 - 41.8)	31.1 (29.5 - 32.8)	38.9 (36 - 41.8)	

Comorbidity in Males

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
Obesity % (CI)		50.1 (45.4 - 54.8)	36.4 (34.3 - 38.6)	48.1 (44.9 - 51.4)	54.6 (51.4 - 57.9)
Dysglycemia % (CI)	24.6 (21.9 - 27.6)		16.9 (15.4 - 18.6)	22.7 (20.1 - 25.5)	18.9 (16.5 - 21.6)
Dyslipidemia % (CI)	80.4 (77.7 - 82.9)	77.3 (73.2 - 80.8)		75.1 (72.2 - 77.8)	80.7 (78.1 - 83.2)
Hypertension % (CI)	49.4 (46.1 - 52.7)	47.4 (42.8 - 52.1)	35.1 (33 - 37.2)		40.7 (37.5 - 43.9)
Central obesity % (CI)	56.1 (52.8 - 59.3)	39.6 (42.8 - 52.1)	37.5 (35.4 - 39.7)	40.7 (37.6 - 44)	

Comorbidity in Females

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
Obesity % (CI)		55.6 (48.2 - 62.8)	32.5 (29.7 - 35.4)	43.9 (36.8 - 51.2)	55.8 (49.7 - 61.8)
Dysglycemia % (CI)	22.8 (19.1 - 27)		13.3 (11.4 - 15.5)	23.5 (18 - 30.1)	22.6 (17.9 - 28.1)
Dyslipidemia % (CI)	77.4 (73.2 - 81.1)	77.5 (70.8 - 83)		75.4 (68.7 - 81)	73.6 (67.9 - 78.6)
Hypertension % (CI)	18.6 (15.2 - 22.6)	24.6 (18.8 - 31.4)	13.8 (11.8 - 16.1)		21.8 (17.2 - 27.4)
Central obesity % (CI)	34 (29.7 - 38.7)	33.5 (26.9 - 40.8)	18.8 (16.6 - 21.4)	29.9 (23.7 - 36.9)	

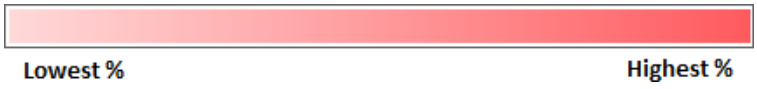


Figure 10: Coexistence of cardiometabolic risk factors.

Comorbidity in Age group 18 - 24 yrs.

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
Obesity % (CI)		40.7 (34.2 - 47.6)	29.3 (26.9 - 31.8)	37.8 (33.4 - 42.5)	55.7 (50.5 - 60.8)
Dysglycemia % (CI)	16.3 (13.3 - 19.7)		10 (8.5 - 11.7)	15.3 (12.3 - 19)	13 (10 - 16.9)
Dyslipidemia % (CI)	74.9 (71 - 78.5)	63.8 (57.2 - 69.9)		63.2 (58.6 - 67.6)	70 (64.9 - 74.3)
Hypertension % (CI)	32.6 (28.6 - 36.8)	32.9 (26.8 - 39.5)	21.6 (19.4 - 23.9)		32 (27.4 - 37.1)
Central obesity % (CI)	39.6 (28.6 - 36.8)	23.4 (18.1 - 29.7)	19.6 (17.6 - 21.9)	26.1 (22.3 - 30.5)	

Comorbidity in Age group 25 - 29 yrs.

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
Obesity % (CI)		55.7 (47.6 - 63.5)	29.3 (26.9 - 31.8)	52.2 (46.2 - 58.2)	55.4 (49.3 - 61.4)
Dysglycemia % (CI)	26.9 (22.3 - 32.2)		17.7 (15.1 - 20.7)	23 (18.4 - 28.4)	20 (15.6 - 25.3)
Dyslipidemia % (CI)	80.5 (75.7 - 84.6)	78.1 (71 - 83.9)		77 (71.6 - 81.6)	77.7 (72.2 - 82.3)
Hypertension % (CI)	45.8 (40.2 - 51.4)	41.7 (34.1 - 49.7)	32.4 (28.9 - 36.1)		32 (27.4 - 37.1)
Central obesity % (CI)	47 (41.5 - 52.7)	34.4 (27.3 - 42.4)	31.3 (27.9 - 35)	35.8 (30.3 - 41.7)	

Comorbidity in Age group 30 - 40 yrs.

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
Obesity % (CI)		58 (51.9 - 63.9)	40.2 (37.3 - 43.3)	54.8 (49.8 - 59.8)	54.1 (49.9 - 58.3)
Dysglycemia % (CI)	30.1 (26.3 - 34.2)		21.7 (19.3 - 24.2)	31.2 (26.8 - 36)	24.2 (20.7 - 28)
Dyslipidemia % (CI)	83.4 (79.9 - 86.4)	87.8 (83.3 - 91.2)		87.5 (83.8 - 90.4)	86.2 (83 - 88.8)
Hypertension % (CI)	42.3 (38 - 46.6)	46.6 (40.6 - 52.6)	32.8 (30 - 35.7)		39.3 (35.3 - 43.5)
Central obesity % (CI)	59.6 (55.2 - 63.9)	51.6 (45.4 - 57.7)	45.7 (42.7 - 48.8)	55.7 (50.6 - 60.6)	

Lowest % Highest %

Figure 11: Coexistence of cardiometabolic risk factors by age groups.

The five metabolic risk factors were then tested for associations with social and behavioral determinants. In the overall study population, smokers had an almost 51% (OR 1.51 (1.18 – 1.92)) increase in the odds of having dyslipidemia and 31% (OR 1.31 (1.01 – 1.70)) increase in the odds of having central obesity compared to nonsmokers. Having a lower educational attainment was associated with an increased odd by 49% (OR 1.49 (1.18-1.87)) for being obese. Being a student had a reduced odd ratio of 0.5 (0.29–0.87) for abnormal glycemia and an increased odd ratio of 1.41 (1.04–1.91) for dyslipidemia, compared to being employed. Participants with a family history of chronic disease had an increase of 40% to 70% in the odds of being obese (OR 1.39

(1.08–1.79)) or hypertensive (OR 1.71 (1.3–2.26)), respectively, compared to people without a family history.

Table 7 shows association between social and behavioral determinants and having cardiometabolic risk factors by gender. In males, a significant association was observed between smoking and dyslipidemia; 1.54 (1.18–2.0). Lower education increased the odds of being obese by 43%; OR 1.43 (1.08–1.90). Being unemployed had a lower odds ratio of 0.56 (0.35–0.90) for obesity and being a student had an odd ratio of 0.44 (0.21–0.89) for dysglycemia. Family history increased the odds of having hypertension by 66% (OR 1.66 (1.22–2.26)).

In females, significant associations were captured between smoking and hypertension by almost 2.5-fold (OR 2.49 (1.10–5.60)). For the social elements, a lower education level showed a significant relationship with obesity and dyslipidemia. Family history increased the odds of having hypertension by more than 2-fold, OR 2.09 (1.07–4.09).

Table 7: Odd ratios of the associations between social and behavioral determinants and having cardiometabolic risk factors.

	Obesity	Dysglycemia	Dyslipidemia	Hypertension	Central obesity
MEN					
Marital Status					
Married	ref	ref	ref	ref	ref
Unmarried	1.06 (0.73-1.54)	1.11 (0.68-1.81)	1.14 (0.79-1.65)	1.25 (0.87-1.80)	0.80 (0.55-1.17)
Employment Status					
Employed	ref	ref	ref	ref	ref
Unemployed	**0.56 (0.35-0.90)**	0.83 (0.46-1.52)	1.02 (0.68-1.52)	0.76 (0.5-1.17)	1.05 (0.70-1.66)
Student	0.89 (0.58-1.38)	**0.44 (0.21-0.89)**	1.33 (0.89-1.99)	0.70 (0.46-1.07)	0.95 (0.59 -1.52)
Education level					
High education	ref	ref	ref	ref	ref
Lower education	**1.43 (1.08-1.90)**	1.06 (0.73-1.55)	1.05 (0.80-1.39)	1.23 (0.94-1.62)	1.11 (0.84-1.48)
Family history of NCDs					
No	ref	ref	ref	ref	ref
Yes	1.34 (0.98-1.83)	1.13 (0.74-1.73)	1.26 (0.95-1.67)	**1.66 (1.22-2.26)**	0.90 (0.68-1.26)
Smoking					
Non-smoking	ref	ref	ref	ref	ref
Smoking	1.04 (0.79-1.37)	0.88 (0.61-1.27)	**1.54 (1.18-2.0)**	0.84 (0.64-1.10)	1.30 (0.99-1.71)
Physical Activity					
Moderate/High	ref	ref	ref	ref	ref
Low PA	1.30 (0.92-1.84)	1.30 (0.79-2.12)	1.03 (0.74-1.43)	0.96 (0.69-1.34)	1.40 (0.98-2.02)
WOMEN					
Marital Status					
Married	ref	ref	ref	ref	ref
Unmarried	0.99 (0.61-1.61)	0.7 0 (0.35-1.40)	0.80 (0.52-1.23)	1.03 (0.56-1.89)	1.01 (0.57-1.81)
Employment Status					
Employed	ref	ref	ref	ref	ref
Unemployed	1.1 (0.66-1.85)	1.15 (0.56-2.36)	1.44 (0.91-2.29)	1.41 (0.74-2.70)	0.92 (0.49-1.80)
Student	0.92 (0.5-1.67)	0.72 (0.28-1.84)	1.40 (0.86-2.29)	1.17 (0.53-2.60)	1.09 (0.60-1.77)
Education level					
High education	ref	ref	ref	ref	ref
Lower education	**1.69 (1.13-2.52)**	1.81 (0.98-3.34)	**1.40 (1.02-1.92)**	1.09 (0.65-1.82)	1.19 (0.71-2.0)
Family history of NCDs					
No	ref	ref	ref	ref	ref
Yes	1.53 (0.97-2.41)	2.09 (0.92-4.78)	1.17 (0.84-1.62)	**2.09 (1.07-4.09)**	1.28 (0.70-2.35)
Smoking					
Non-smoking	ref	ref	ref	ref	ref
Smoking	1.54 (0.75-3.15)	2.02 (0.78-5.22)	1.27 (0.66-2.42)	**2.49 (1.10-5.60)**	1.49 (0.62-3.5)
Physical Activity					
Moderate/High	ref	ref	ref	ref	ref
Low PA	0.95 (0.59-1.53)	0.69 (0.35-1.37)	0.74 (0.52-1.11)	1.02 (0.54-1.93)	1.71 (0.84-3.5)

Data is presented here as odd ratios (CI). Estimated values are derived from a multivariate adjustment for age, gender, smoking, low physical activity, education, marital status, employment and family history,

Table 8 presents the associations between the five cardiometabolic risk factors adjusting only for age and gender. Since smoking, educational level and family history showed significant associations with some metabolic risk factors, they were included in the multivariate models presented in Table 9.

Table 8: Odd ratios of the associations between the cardiometabolic risk factors adjusted for age and sex.

Total population

Dysglycemia	2.98 (2.49-3.55)			
Dyslipidemia	2.71 (2.32-3.15)	1.85 (1.51-2.26)		
Hypertension	3.03 (2.61-3.52)	2.32 (1.92-2.79)	1.81 (1.54-2.12)	
Central obesity	4.70 (4.04-5.46)	1.57 (1.29-1.9)	2.18 (1.85-2.56)	1.85 (1.58-2.17)
	Obesity	**Dysglycemia**	**Dyslipidemia**	**Hypertension**

MEN

Dysglycemia	2.54 (2.06-3.14)			
Dyslipidemia	2.38 (1.96-2.89)	1.55 (1.22-1.97)		
Hypertension	3.19 (2.69-3.77)	2.18 (1.78-2.68)	1.67 (1.4-2.0)	
Central obesity	4.72 (3.95-5.65)	1.29 (1.03-1.61)	2.10 (1.73-2.55)	1.77 (1.49-2.11)
	Obesity	**Dysglycemia**	**Dyslipidemia**	**Hypertension**

WOMEN

Dysglycemia	2.54 (2.06-3.14)			
Dyslipidemia	2.38 (1.96-2.89)	1.55 (1.22-1.97)		
Hypertension	3.19 (2.69-3.77)	2.18 (1.78-2.68)	1.67 (1.40-2.0)	
Central obesity	4.72 (3.95-5.65)	1.29 (1.03-1.61)	2.10 (1.73-2.55)	1.77 (1.49-2.11)
	Obesity	**Dysglycemia**	**Dyslipidemia**	**Hypertension**

Data is presented as odds ratios (95% CI). Multivariate models adjusted for age and gender only. For each risk factor, the reference groups were those without that risk factor.

All associations were found significant, however, when the model was adjusted for all risk factors including smoking, education and family history, the associations were attenuated, but remained significant with the exception of central obesity with dysglycemia in both men and women, and with dyslipidemia in females, Table 9. The strongest relationship was captured with obesity. For instance, obesity was associated with 4-fold increase in the odds of having central obesity (OR 4.21 (3.5 – 5.06)), and over 2-fold increase odds of having abnormal glycemic status (2.59 (2.06 – 3.24)), hypertension (OR (2.35 (1.95–2.84)), and dyslipidemia (OR 2.08 (2.06 – 3.24)).

Table 9: Odd ratios of the associations between different cardiometabolic risk factors adjusted for age, sex and each other.

TOTAL POPULATION

Dysglycemia	2.59 (2.06-3.24)			
Dyslipidemia	2.08 (1.72-2.52)	1.56 (1.22-1.99)		
Hypertension	2.35 (1.95-2.84)	1.92 (1.54-2.39)	1.42 (1.17-1.71)	
Central obesity	4.21 (3.50-5.06)	0.93 (0.74-1.18)	1.54 (1.26-1.88)	1.35 (1.11-1.64)
	Obesity	**Dysglycemia**	**Dyslipidemia**	**Hypertension**

MEN

Dysglycemia	2.25 (1.73-2.95)			
Dyslipidemia	1.92 (1.51-2.45)	1.38 (1.03-1.85)		
Hypertension	2.61 (2.12-3.23)	1.92 (1.5-2.47)	1.35 (1.09-1.68)	
Central obesity	4.27 (3.44-5.30)	0.86 (0.66-1.13)	1.56 (1.23-1.98)	1.23 (1.01-1.49)
	Obesity	**Dysglycemia**	**Dyslipidemia**	**Hypertension**

WOMEN

Dysglycemia	3.51 (2.31-5.35)			
Dyslipidemia	2.42 (1.77-3.30)	1.96 (1.24-3.11)		
Hypertension	1.58 (1.05-2.37)	2.11 (1.31-3.41)	1.89 (1.26-2.86)	
Central obesity	4.21 (2.95-6.02)	1.33 (0.83-2.13)	1.39 (0.96-2.02)	1.65 (1.05-2.57)
	Obesity	**Dysglycemia**	**Dyslipidemia**	**Hypertension**

Data is presented as odds ratios (CI). Multivariate adjustment for age, gender, obesity, abnormal glycemic status, hypertension, dyslipidemia and central obesity, as well as educational level, smoking status and family history.

5.2 Objective 2: Describe the burden of cardiometabolic risk factors

The burden of cardiometabolic risk factors was measured as the number of risk factors per subject. Quarter of the population (25.5%) had zero risk factors. The remaining population had a range from 1 to 5 risk factors. The majority of the sample had either 1 risk factor (34.2%) or 2 risk factors (20.5%) as displayed in Figure 12.

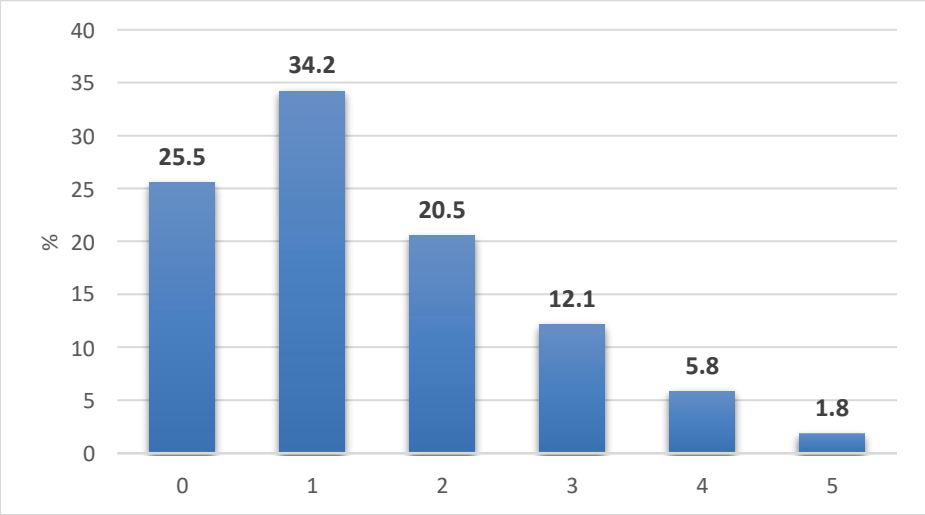


Figure 12: Burden of cardiometabolic risk factors.

The distribution of number of risk factors in men and women is visualized in Figure 13. Males in this sample had more risk factors than females; 81% of men had at least one risk factor versus 64% of women. With the exception of having only one risk factor, the proportions of men suffering from a burden of having two to five risk factors were consistently higher than women in this study population.

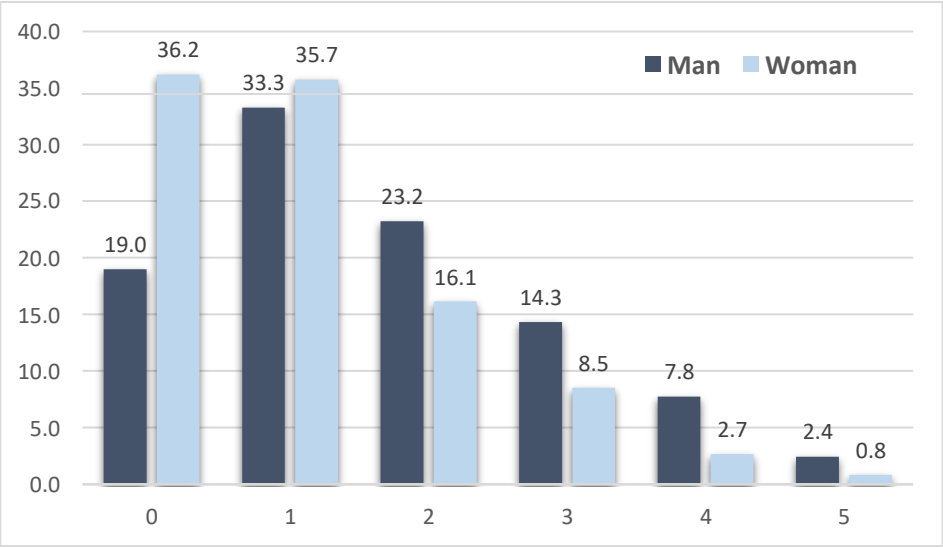


Figure 13: Burden of risk factors in men and women of the sample.

Figure 14 shows the distribution of the burden of the cardiometabolic risk factors within age groups. It shows that in the older age groups, the proportion of accumulated risk factors increases. This was similar for the whole population and in men and women. Interestingly, men with five risk factors were all older than 20 years, however, a proportion of women aged 18 to 20 years was already having a burden of 5 cardiometabolic risk factors.

The burden of the risk factors was dichotomized to “0-1 RFs” and “≥2 RFs”. Sixty percent of the population had 0-1 risk factors. Men had a higher burden of risk factors compared to women across all age groups. Figure 15 shows the proportions of risk factors across age groups. As age increased, the proportion of people with ≥2 risk factors increased.

P value = 0.00

Figure 14: Burden of risk factors in different age groups.

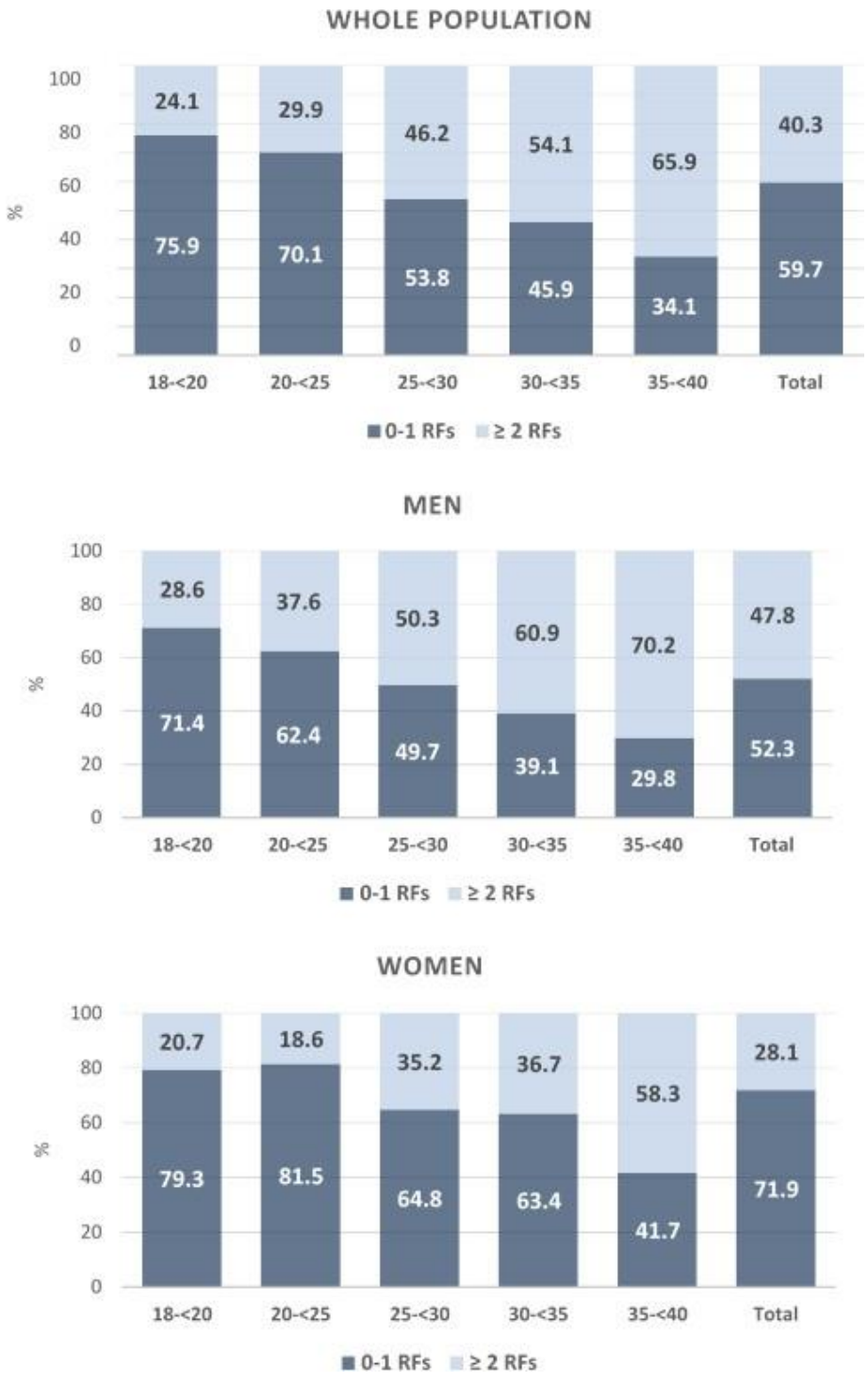


Figure 15: Burden of risk factors: age groups and gender

Univariate associations between social and behavioral determinants with having ≥ 2 cardiometabolic risk factors as the outcome is presented in Table 10. Most

factors were significantly associated with the outcome, except for low physical activity. Whereas the adjusted multivariate model in Table 11 shows that only age, educational level, and family history were significantly associated with the outcome after adjustment for age and other factors. For every 1-year increase in age, there is a 10% increase in the odds of having ≥ 2 cardiometabolic risk factors (OR 1.1 (1.08 – 1.13)). Not being a college graduate increased the odds of having ≥ 2 cardiometabolic risk factors by 37% (OR 1.37 (1.1 – 1.69)), while having a parent with NCD increased the odds by 44% (OR 1.44 (1.14 – 1.81)).

Table 10: Unadjusted odd ratios of social and behavioral factors associated with having ≥ 2 cardiometabolic risk factors.

	All OR (95% CI)	**Men OR (95% CI)**	**Women OR (95% CI)**
Age	1.11 (1.09 - 1.12)	1.1 (1.08 - 1.11)	1.1 (1.08 - 1.12)
Marital status			
Married (Ref)			
Single / divorced	0.38 (0.34 - 0.43)	0.47 (0.40 - 0.55)	0.38 (0.30 - 0.49)
Employment level			
Employed (Ref)			
Unemployed	0.58 (0.49 - 0.70)	0.57 (0.45 - 0.74)	0.87 (0.65 - 1.16)
Student	0.32 (0.27 - 0.38)	0.50 (0.40 - 0.62)	0.34 (0.26 - 0.45)
Education level			
Bachelors & above (Ref)			
High school & below	1.03 (0.91 - 1.16)	0.89 (0.77 - 1.04)	1.26 (1.02 - 1.56)
Family history			
No (Ref)			
Yes	1.63 (1.45 - 1.83)	1.74 (1.51 - 2.01)	1.80 (1.46 - 2.2)
Smoking			
Non-smoking (Ref)			
Smoking	2.10 (1.83 - 2.40)	1.41 (1.20 - 1.65)	1.82 (1.15 - 2.89)
physical activity			
Mod-high PA (Ref)			
Low PA	1.12 (0.92 - 1.37)	1.21 (0.94 - 1.55)	1.05 (0.73 - 1.50)

Data is presented as unadjusted odds ratios (CI). Univariate analysis for each factor with having ≥2 CRF as an outcome.

In men, only age and family history showed an association with having a burden of 2 or more cardiometabolic risk factors. Odd ratio for age was 1.1 (1.06 – 1.13), and positive family history of NCD increased the odds by 37% (OR 1.37 (1.04

– 1.8)). For women, age accounted for a 12% increase in the odds (OR 1.12 (1.08 – 1.17)). Having a lower educational level accounted for 61% increase in the odds (OR 1.61 (1.1 – 2.34)) and family history of NCD accounted for 64% increase (OR 1.64 (1.07 – 2.51)).

Table 11: Adjusted odd ratios of social and behavioral factors associated with having ≥ 2 cardiometabolic risk factors.

	All OR (95% CI)	**Men** OR (95% CI)	**Women** OR (95% CI)
Age:	**1.1 (1.08 - 1.13)**	**1.1 (1.06 - 1.13)**	**1.12 (1.08 - 1.17)**
Marital status			
Married (Ref)			
Single	0.97 (0.74 - 1.26)	1.07 (0.76 - 1.5)	0.83 (0.53 - 1.31)
Employment level			
Employed (Ref)			
Unemployed	1.05 (0.78 - 1.42)	0.79 (0.52 - 1.18)	1.41 (0.86 - 2.32)
Student	1.16 (0.84 - 1.59)	1.11 (0.75 - 1.64)	1.34 (0.76 - 2.38)
Education level			
Bachelors & above (Ref)			
High school & below	1.37 (1.1 - 1.69)	1.28 (0.99 - 1.66)	**1.61 (1.1 - 2.34)**
Family history			
No (Ref)			
Yes	**1.44 (1.14 - 1.81)**	**1.37 (1.04 - 1.8)**	**1.64 (1.07 - 2.51)**
Smoking			
Non-smoking (Ref)			
Smoking	1.22 (0.97 - 1.54)	1.18 (0.92 - 1.52)	1.89 (0.97 - 3.68)
Physical activity			
Mod-high PA (Ref)			
Low PA	1.17 (0.90 - 1.52)	1.31 (0.95 - 1.79)	0.97 (0.62 - 1.52)

Data is presented as adjusted odds ratios (CI). Multivariate analysis for each factor with having ≥2 MRF as an outcome. Model is adjusted for age, gender as well as employment, education, marital status, smoking, physical activity and family history.

5.3 Objective 3: Investigate the effect of BMI on the other cardiometabolic risk factors and their burden

Around two-thirds of the population were either overweight (30.8%) or obese (27.2%), as shown in Figure 16. Across genders, there were more men in the overweight and obese categories than women, as shown in Figure 17.

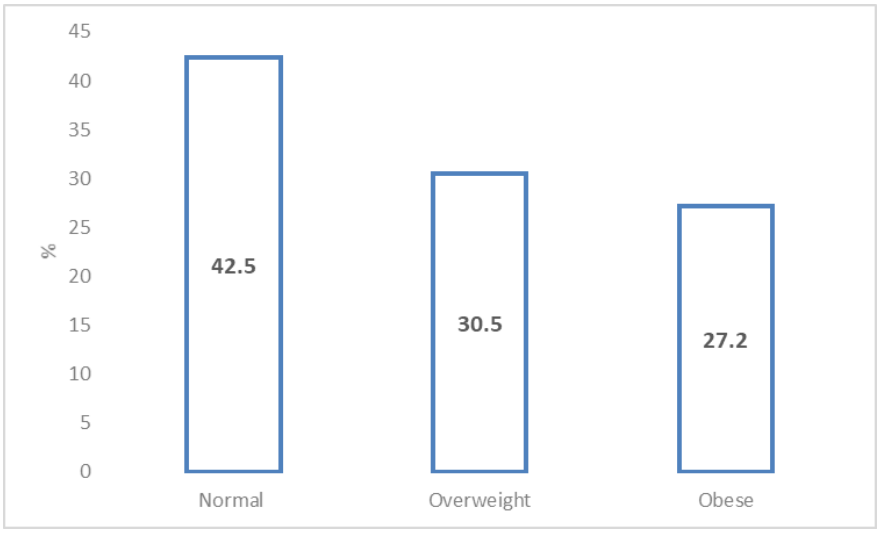


Figure 16: Body Mass Index classification of the study population.

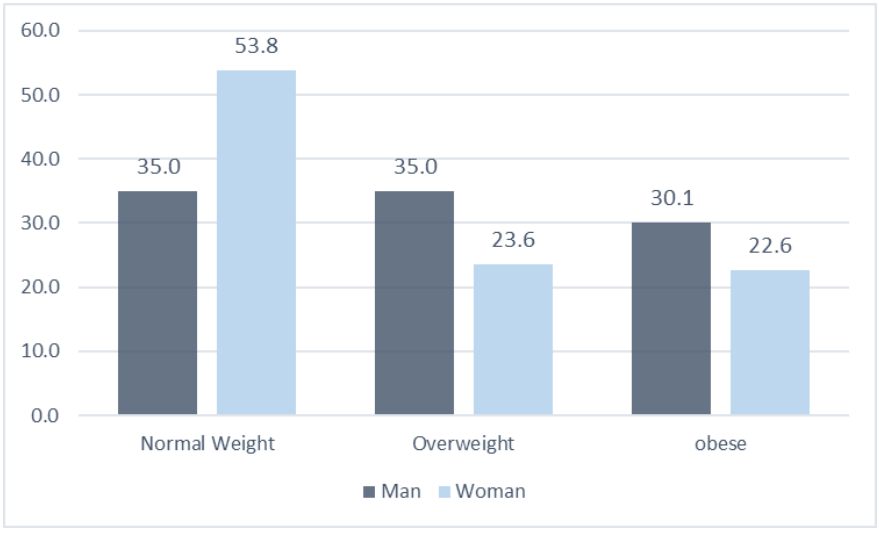
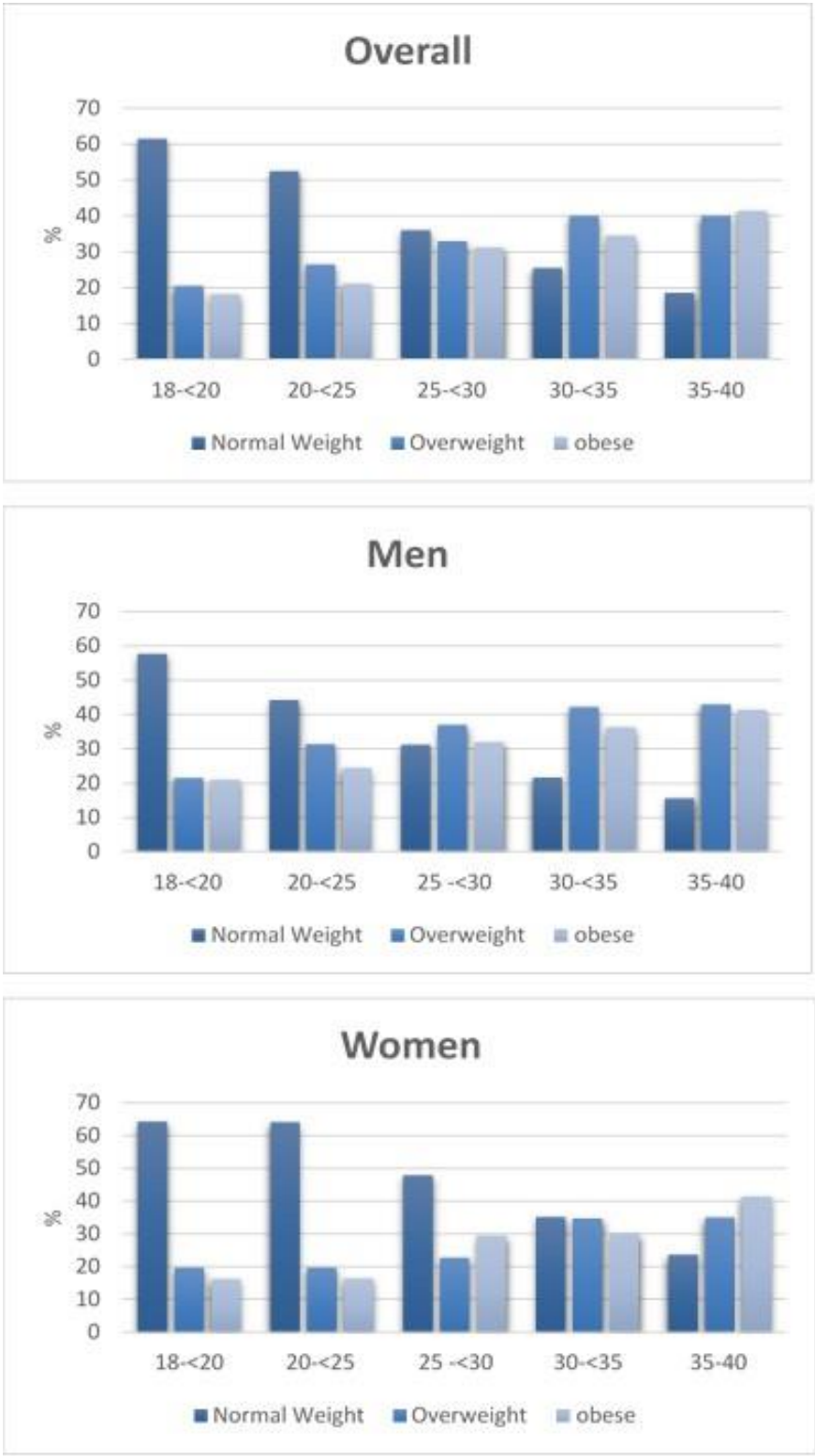


Figure 17: Body Mass Index categories distribution in men and women.



P value= 0.0

Figure 18: Distribution of BMI across age groups and sexes

Linear regression models showed an odd ratio of 1.30 (1.26 – 1.34) for age as an exposure variable and BMI as an outcome. Figure 18 shows that overweight and obesity proportions increase significantly as age increases in the whole population, as well as in each sex.

Tables 12 and 13 show the difference in the distribution of cardiometabolic risk factors across the BMI classes and age groups in men and women; respectively. The mean values for cardiometabolic markers change between BMI classes, this change is also reflected when the measurement values are converted to categorical definitions.

In both men and women, the proportion of those with an abnormal HbA1c increased from 15% in the normal BMI group, to 24-27% in the overweight group, and 57-60% in the obese group. Fasting glucose levels also increase as BMI increases. The youngest age group had higher glycemia rates in the normal-BMI class than other classes.

Lipid markers also differ across the BMI groups. Mean values for lipid markers increase as BMI increases. In both men and women below 20 years, it was observed that more glucose and lipid abnormalities within the normal BMI groups than overweight and obese groups.

Blood pressure measurements, systolic blood pressure and diastolic blood pressure increase significantly from normal, to overweight to obese classes. In men, elevated blood pressure increases from 17.2% in the normal BMI, to 34.7% in the overweight, to 48.1% in the obese group. In women, it increases from 28.3% to 27.8% to 43.9% in the normal, overweight and obese groups, respectively.

Waist-to-hip ratios also significantly increase as BMI increases. Central obesity increases in men from 13.2% to 32.2% to 54.6% from the normal BMI to the

overweight and obese, respectively. The pattern is similar for women as well, as shown in Table 13. After stratifying by age group, women in the young populations (age 18 - < 25) had higher percentages of people with central obesity in the normal group than in the overweight group observed. In men, this was seen only in the 18-20 age group.

Table 12: Cardiometabolic risk factors by BMI class and age groups in men.

	Total	BMI class			P-value
		Normal	Overweight	Obese	
HbA1c, %	5.29 (0.69)	5.18 (0.64)	5.24 (0.55)	5.47 (0.85)	0.00
Elevated HbA1c					
All	270	41 (15.2%)	75 (27.8%)	154 (57%)	0.00
18 - <20	14	5 (35.7%)	1 (7.1%)	8 (57.1%)	0.005
20-<25	45	13 (28.9%)	16 (35.6%)	16 (35.6%)	0.067
25-<30	60	8 (13.3%)	14 (23.3%)	38 (63.3%)	0.00
30-<35	76	9 (11.8%)	23 (30.0%)	44 (57.9%)	0.00
35-40	75	6 (8%)	21 (28%)	48 (64%)	0.00
Fasting glucose mg/dL	96.5 (25.7)	94.2 (26.2)	93.6 (9.8)	101.6 (32.7)	0.00
Elevated FBG					
All	185	56 (30.3)	50 (27%)	79 (42.7%)	0.001
18 - <20	17	13 (76.5%)	2 (11.8%)	2 (11.8%)	0.170
20-<25	60	16 (26.7%)	19 (31.7%)	25 (41.7%)	0.005
25-<30	62	15 (24.2%)	16 (25.8%)	31 (50%)	0.039
30-<35	31	11 (35.5%)	11 (35.5%)	9 (29%)	0.856
35-40	15	1 (6.7%)	2 (13.3%)	12 (80%)	0.158
LDL mg/dL	121.6 (35.7)	110.7(33.5)	125.3 (34.4)	129.8 (36.5)	0.00
Abnormal LDL					
All	1,232	275(22.3%)	475 (38.6%)	482 (39.1%)	0.00
18 - <20	68	29 (42.7%)	18 (26.5%)	21 (30.9%)	0.017
20-<25	329	100(30.4%)	110 (33.4%)	119 (36.2%)	0.00
25-<30	309	69 (22.3%)	118 (38.2%)	122 (39.5%)	0.00
30-<35	303	45 (14.9%)	127 (41.9%)	131 (43.2%)	0.00
35-40	223	32 (14.4%)	102 (45.7%)	89 (39.9%)	0.383
HDL mg/dL	43.9 (10.5)	47.1 (10.6)	43.4 (10.8)	40.8 (9)	0.00
Abnormal HDL					
All	1,331	305(22.9%)	486 (36.5%)	540 (40.6%)	0.00
18 - <20	125	54 (43.2%)	32 (25.6%)	39 (31.2%)	0.00
20-<25	374	118(31.6%)	123 (32.9%)	133 (35.6%)	0.00
25-<30	321	64 (19.9%)	120 (37.4%)	137 (42.7%)	0.00
30-<35	287	49 (17.1%)	115 (40.1%)	123 (42.9%)	0.001
35-40	224	20 (8.9%)	96 (42.9%)	108 (48.2%)	0.00
Cholesterol mg/dL	185.6 (38.6)	174.9(36.2)	189.9 (37.8)	192.9(39.5)	0.00
Abnormal total Cholesterol					
All	1,120	250 (22.3%)	438 (39.1%)	432 (38.6%)	0.00
18 - <20	44	17 (38.6%)	10 (22.7%)	17 (38.6%)	0.005
20-<25	293	91 (31.1%)	96 (32.8%)	106 (36.2%)	0.00
25-<30	281	65 (23.1%)	105 (37.4%)	111 (39.5%)	0.00
30-<35	286	44 (15.4%)	127 (44.4%)	115 (40.2%)	0.001
35-40	216	33 (15.3%)	100 (46.3%)	83 (38.4%)	0.270

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Table 12: Cardiometabolic risk factors distribution by BMI class and age groups in men (Continued)

	Total	BMI class			P-value
		Normal	**Overweight**	**Obese**	
Triglycerides mg/dL	119.1 (85.7)	89.0 (65.0)	124.2 (84.4)	148 (96.6)	0.00
Abnormal TG					
All	513	214(41.7%)	131 (25.5%)	168 (32.8%)	0.00
18 - <20	45	19 (42.2%)	9 (20%)	17 (37.8%)	0.010
20-<25	194	45 (23.2%)	70 (36.1%)	79 (40.7%)	0.00
25-<30	205	32 (15.6%)	78 (38.1%)	95 (46.3%)	0.00
30-<35	220	29 (13.2%)	92 (41.8%)	99 (45%)	0.00
35-40	185	13 (7%)	75 (40.5%)	97 (52.4%)	0.00
Systolic BP, mmHg	131.2 (13.1)	125 (11.4)	132 (12.1)	137.5 (12.6)	0.00
Diastolic BP, mmHg	80.3 (10.2)	76.6 (8.9)	80.3 (9.9)	84.7 (10.3)	0.00
Elevated blood pressure					
All	902	155 (17.2%)	313 (34.7%)	434 (48.1%)	0.00
18 - <20	78	27 (34.6%)	20 (25.6%)	31 (39.7%)	0.00
20-<25	278	62 (22.3%)	108 (38.9%)	108 (38.9%)	0.00
25-<30	233	36 (15.5%)	78 (33.5%)	119 (51.1%)	0.00
30-<35	175	21 (12%)	59 (33.7%)	95 (54.3%)	0.00
35-40	138	9 (6.5%)	48 (34.8%)	81 (58.7%)	0.00
Waist-Hip Ratio	0.87 (0.07)	0.83 (0.07)	0.87 (0.7)	0.91 (0.06)	0.00
Central obesity					
All	895	118 (13.2%)	288 (32.2%)	489 (54.6%)	0.00
18 - <20	41	8 (19.5%)	7 (17.1%)	26 (63.4%)	0.00
20-<25	214	39 (18.2%)	56 (26.2%)	119 (55.6%)	0.00
25-<30	214	27 (12.6%)	71 (33.2%)	116 (54.2%)	0.00
30-<35	232	26 (11.2%)	81 (34.9%)	125 (53.9%)	0.00
35-40	194	18 (9.3%)	73 (37.6%)	103 (53.1%)	0.00

Data is presented here as means (standard deviations) or N (%). P values are derived from ANOVA, chi-square tests and Fisher-exact tests. Elevated blood pressure is based on systolic and diastolic blood pressure, as well as, self-report and use of medication.

Table 13: Cardiometabolic risk factors by BMI class and age groups in women.

	Total	**BMI class**			**P-value**
		Normal	**Overweight**	**Obese**	
HbA1c, %	5.215 (0.58)	5.11 (0.48)	5.23 (0.50)	5.45 (0.78)	0.00
Elevated HbA1c					
All	129	20 (15.5%)	31 (24%)	78 (60.5%)	0.00
18 - <20	23	11 (47.8%)	5 (21.7%)	7 (30.4%)	0.117
20-<25	23	4 (17.4%)	5 (21.7%)	14 (60.9%)	0.00
25-<30	22	3 (13.6%)	3 (13.6%)	16 (72.7%)	0.00
30-<35	22	0	6 (27.3%)	16 (72.7%)	0.00
35-40	39	2 (5.1%)	12 (30.8%)	25 (64.1%)	0.002
Fasting glucose mg/dL	88.8 (22.3)	84.2 (7.7)	91.9 (23)	95.6 (37.1)	0.00
Elevated FBG					
All	31	5 (16.1%)	14 (45.2%)	12 (38.7%)	0.00
18 - <20	3	2 (66.7%)	0	1 (33.3%)	0.412
20-<25	7	0	3 (42.9%)	4 (57.1%)	0.005
25-<30	7	3 (42.9%)	2 (28.6%)	2 (28.6%)	0.811
30-<35	4	0	3 (75%)	1 (25%)	0.053
35-40	10	0	6 (60%)	4 (40%)	0.182
LDL mg/dL	106.0(28.13)	99.7 (25.3)	108.6 (28.3)	118.3 (29.9)	0.00
Abnormal LDL					
All	454	160 (35.2%)	123 (27.1%)	171 (37.7%)	0.00
18 - <20	81	44 (54.3%)	13 (16.1%)	24 (29.6%)	0.001
20-<25	132	60 (45.5%)	30 (22.7%)	42 (31.8%)	0.00
25-<30	81	24 (29.6%)	24 (29.6%)	33 (40.7%)	0.001
30-<35	62	15 (24.2%)	22 (35.5%)	25 (40.3%)	0.053
35-40	98	17 (17.4%)	34 (34.7%)	47 (48%)	0.129
HDL mg/dL	55.8 (13)	58.9 (12.4)	54.8 (13)	49.5 (11.8)	0.00
Abnormal HDL					
All	773	289 (37.4%)	204 (26.4%)	280 (36.2%)	0.00
18 - <20	184	87 (47.3%)	43 (23.4%)	54 (29.4%)	0.00
20-<25	256	125 (48.8%)	61 (23.8%)	70 (27.3%)	0.00
25-<30	129	35 (27.1%)	32 (24.8%)	62 (48.1%)	0.00
30-<35	92	25 (27.2%)	33(35.9%)	34 (37%)	0.067
35-40	112	17 (15.2%)	35 (31.3%)	60 (53.6%)	0.00
Cholesterol mg/dL	177.1 (30.3)	172.7(28.1)	179.6 (31.2)	185.1 (32.7)	0.00
Abnormal total Cholesterol					
All	513	214 (41.7%)	131 (25.5%)	168 (32.8%)	0.00
18 - <20	89	52 (58.4%)	15 (16.9%)	22 (24.7%)	0.046
20-<25	147	80 (54.4%)	26 (17.7%)	41 (27.9%)	0.00
25-<30	87	34 (39.1%)	22 (25.3%)	31 (35.6%)	0.177
30-<35	82	23 (28.1%)	31 (37.8%)	28 (34.2%)	0.217
35-40	108	25 (23.2%)	37 (34.3%)	46 (42.6%)	0.923

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Table 13: Cardiometabolic risk factors by BMI class and age groups in women. (Continued)

	Total	BMI class			P-value
		Normal	**Overweight**	**Obese**	
Triglycerides mg/dL	79.3 (52.8)	64.7 (36.9)	85.1 (57.8)	108.2 (65.4)	0.00
Abnormal TG					
All	281	86 (30.6%)	76 (27.1%)	119 (42.4%)	0.00
18 - <20	50	26 (50%)	8 (16%)	16 (32%)	0.005
20-<25	65	25 (38.5%)	17 (26.2%)	23 (35.4%)	0.00
25-<30	50	16 (32%)	12 (24%)	22 (44%)	0.033
30-<35	49	10 (20.4%)	18 (36.7%)	21 (42.9%)	0.026
35-40	67	9 (13.4%)	21 (31.3%)	37 (55.2%)	0.014
Systolic BP, mmHg	117.8 (11.5)	113.4 (9.7)	119.5(10.2)	126 (11.7)	0.00
Diastolic BP, mmHg	74.3 (9.3)	72 (7.5)	75.5 (8.6)	78.5 (9.3)	0.00
Elevated blood pressure					
All	180	51 (28.3%)	50 (27.8%)	79 (43.9%)	0.00
18 - <20	33	15 (45.5%)	8 (24.2%)	10 (30.3%)	0.033
20-<25	42	20 (47.6%)	8 (19.1%)	14 (33.3%)	0.010
25-<30	35	7 (20%)	7 (20%)	21 (60%)	0.00
30-<35	24	3 (12.5%)	10 (41.7%)	11 (45.8%)	0.031
35-40	46	6 (13%)	17 (37%)	23 (50%)	0.139
Waist-Hip Ratio	0.77 (0.08)	0.74 (0.07)	0.77 (0.07)	0.81 (0.08)	0.00
Central obesity					
All	258	54 (20.9%)	60 (23.3%)	144 (55.8%)	0.00
18 - <20	43	13 (30.2%)	9 (20.9%)	21 (48.8%)	0.00
20-<25	59	18 (30.5%)	8 (16.6%)	33 (55.9%)	0.00
25-<30	44	7 (15.9%)	10 (22.7%)	27 (61.4%)	0.00
30-<35	44	6 (13.6%)	13 (29.6%)	25 (56.8%)	0.00
35-40	68	10 (14.7%)	20 (29.4%)	38 (55.9%)	0.007

Data is presented here as means (standard deviations) or N (%). P values are derived from ANOVA, chi-square tests and Fisher-exact tests. Elevated blood pressure is based on systolic and diastolic blood pressure, as well as, self-report and use of medication.

Tables 14 and 15 present the unadjusted and age-adjusted prevalence rates for each metabolic risk factor by BMI class, in men and women, respectively. The prevalence of all risk factors significantly increase as the BMI increases. Obesity had the highest prevalence rates of cardiometabolic risk factors in men and women; this is visualized in Figure 19. In the overall sample, among the obese, 51.7% had dysglycemia, 35.1% had dyslipidemia, 47.4% were hypertensive and 55% had central obesity. The trends were similar in men and women.

Table 14: Unadjusted and age-adjusted prevalence of cardiometabolic risk factors by BMI class in Men.

	Total % (95% CI)	**Normal % (95% CI)**	**Overweight % (95% CI)**	**Obese % (95% CI)**
Elevated HbA1c				
Unadjusted	9.35 (8.4-10.4)	4.0 (2.8-5.2)	7.4 (5.8-9.0)	17.5 (15.0-20.1)
Age-adjusted	8.1 (7.1-9.1)	4.4 (3.1-5.7)	6.0 (4.6-7.4)	14.6 (12.2-17.0)
Abnormal FBG				
Unadjusted	24.4 (21.4-27.5)	18.4 (14.0-22.7)	23.8 (18.0-29.6)	32.4 (26.5-38.2)
Age-adjusted	24.1 (21.0-27.1)	19.0 (14.5-23.5)	23.2 (17.5-28.9)	30.9 (25-36.8)
Abnormal LDL				
Unadjusted	42.5 (40.8-44.2)	27.0 (24.3-29.8)	46.6 (43.5-49.6)	54.8 (51.5-58.1)
Age-adjusted	42.1 (40.3-43.9)	29.9 (26.9-32.9)	44.4 (41.2-47.5)	52.5 (49.1-55.9)
Abnormal HDL				
Unadjusted	45.5 (43.7-47.2)	30.0 (27.2-32.8)	47.6 (44.6-50.7)	61.3 (58.1-64.5)
Age-adjusted	45.4 (43.6-47.1)	31.7 (28.8-34.7)	46.5 (43.4-49.6)	60.2 (56.9-63.5)
Abnormal total Cholesterol				
Unadjusted	38.0 (36.3-39.7)	24.6 (21.9-27.2)	42.9 (40.0-46.0)	49.0 (45.7-52.3)
Age-adjusted	37.2 (35.4-38.9)	27.4 (24.5-30.4)	40.2 (37.1-43.3)	46.1 (42.6-49.5)
Abnormal TG				
Unadjusted	28.2 (26.6-29.7)	13.6 (11.5-15.7)	31.8 (29.0-34.7)	44.0 (40.7-47.3)
Age-adjusted	26.7 (25.1-28.3)	14.0 (12.7-17.3)	29.1 (26.2-32.0)	41.0 (37.6-44.3)
Elevated BP				
Unadjusted	27.9 (26.3-29.5)	13.1 (11.1-15.2)	27.5 (24.7-30.2)	45.3 (42.0-48.6)
Age-adjusted	27.7 (26.1-29.3)	13.3 (11.2-15.5)	27.3 (24.5-30.1)	45.0 (41.7-48.3)
Central obesity				
Unadjusted	30.9 (29.3-32.6)	11.6 (9.6-13.5)	28.9 (26.0-31.7)	56.1 (52.8-59.4)
Age-adjusted	29.6 (27.9-31.3)	12.7 (10.6-14.9)	25.9 (23.1-28.7)	53.6 (50.2-57.1)

Table 15: Unadjusted and age-adjusted prevalence of cardiometabolic risk factors by BMI class in Women.

	Total % (95% CI)	Normal % (95% CI)	Overweight % (95% CI)	Obese % (95% CI)
Elevated HbA1c				
Unadjusted	6.9 (5.8-8.1)	2.0 (1.1-2.8)	7.1 (4.7-9.5)	18.4 (14.7-22.1)
Age-adjusted	5.9 (4.8-7.0)	2.1 (1.2-3.0)	5.9 (3.7-8.0)	15.1 (11.6-18.7)
Abnormal FBG				
Unadjusted	10.5 (7.0-14.0)	3.4 (0.5-6.3)	19.2 (10.1-28.2)	17.6 (8.6-26.7)
Age-adjusted	9.1 (5.6-12.5)	3.6 (0.5-6.7)	16.3 (7.6-25)	14.7 (6.3-23.2)
Abnormal LDL				
Unadjusted	23.9 (22.0-25.8)	15.8 (13.5-18.1)	27.8 (23.7-32.1)	40.1 (35.5-44.8)
Age-adjusted	22.9 (20.9-24.8)	16.8 (14.4-19.1)	25.4 (21.3-29.5)	36.3 (31.6-41.1)
Abnormal HDL				
Unadjusted	41.2 (39.0-43.4)	28.5 (25.7-31.2)	46.2 (41.5-50.8)	65.7 (61.2-70.2)
Age-adjusted	41.1 (38.9-43.3)	28.7 (25.9-31.6)	45.9 (41.2-50.6)	65.3 (60.7-69.9)
Abnormal total Cholesterol				
Unadjusted	27.0 (25.1-29.0)	21.1 (18.6-23.6)	29.6 (25.4-33.9)	39.4 (34.8-44.1)
Age-adjusted	26.0 (24.0-28.0)	22.7 (20-25.4)	26.3 (22.1-30.5)	34.6 (29.9-39.2)
Abnormal TG				
Unadjusted	14.8 (13.2-16.3)	8.5 (6.8-10.2)	17.2 (13.7-20.7)	27.9 (23.7-32.2)
Age-adjusted	13.5 (11.9-15.1)	9.0 (7.2-10.8)	14.8 (11.5-18.1)	23.8 (19.6-28.0)
Elevated BP				
Unadjusted	5.9 (4.8-7.0)	1.8 (1.0-2.7)	6.5 (4.1-8.8)	14.5 (11.1-17.8)
Age-adjusted	5.2 (4.1-6.3)	1.9 (1.0-2.8)	5.6 (3.5-7.8)	12.3 (9.0-15.5)
Central obesity				
Unadjusted	13.9 (12.3-15.4)	5.5 (4.0-6.9)	13.8 (10.6-17.1)	34 (29.5-38.6)
Age-adjusted	12.5 (10.9-14)	5.8 (4.3-7.3)	11.9 (8.9-14.9)	30.1 (25.5-34.6)

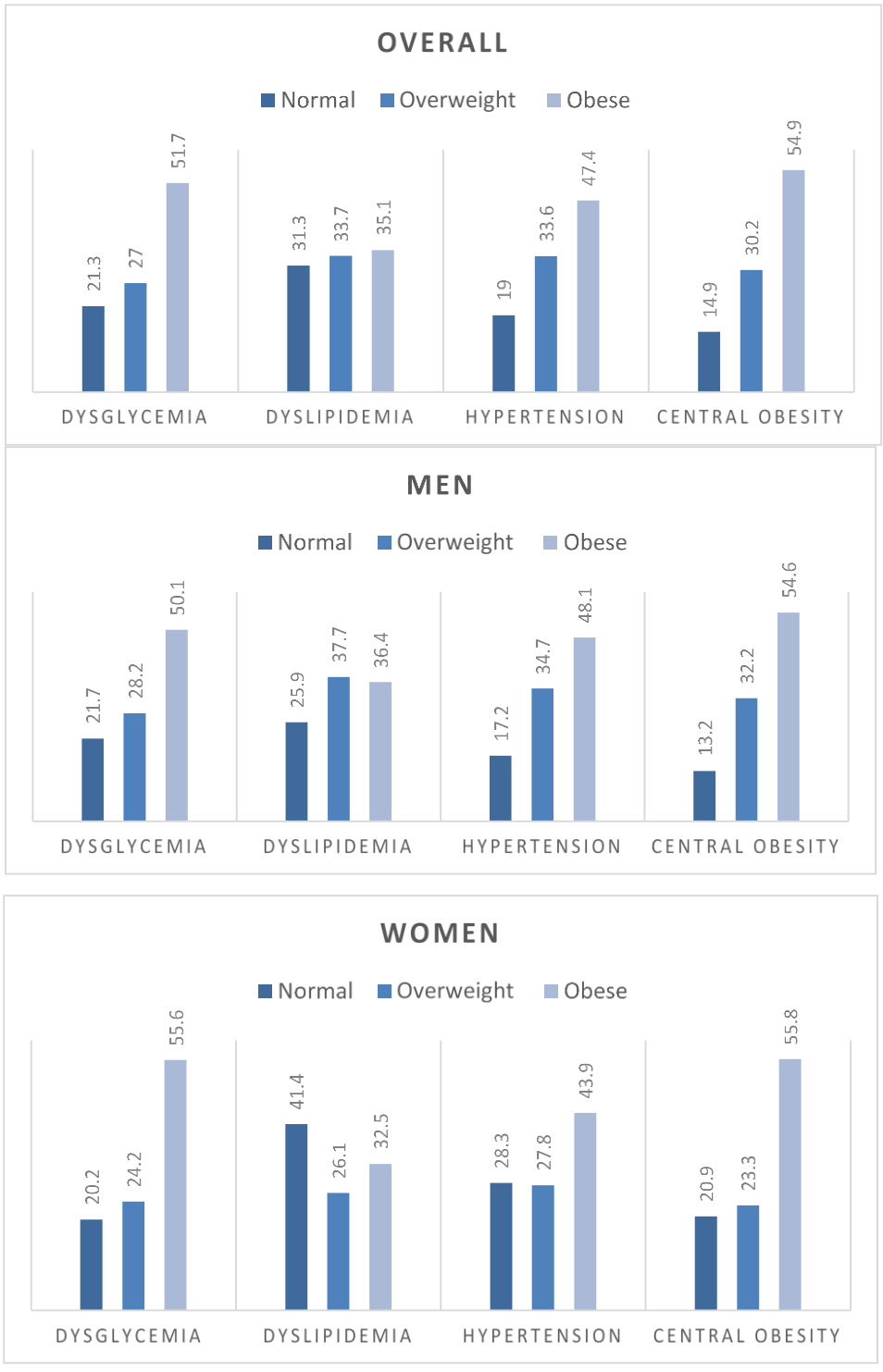

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Figure 19: Distribution of cardiometabolic risk factors across BMI groups and Gender.

Figure 20 shows as BMI increases people tend to accumulate more risk factors. Grouping the 4 remaining metabolic risk factors; dysglycemia, dyslipidemia, hypertension and central obesity, into 2 groups; 0-1 Risk factors and 2-4 Risk factors, allowed to show the difference in the burden based on BMI classes. Figure 21 shows the burden of risk factors similarly increases as the BMI increases, in the whole population, as well as, in each sex. Thirteen percent of the normal-BMI population had an accumulation of 2 or more risk factors, 37% in the overweight and 63% in the obese. In men, interestingly 20% of those with normal BMI already had two or more other cardiometabolic risk factors, and the proportion increased to 71.4% in the obese group. Only forty-five percent of obese women had an accumulation of 2-4 metabolic risk factors.

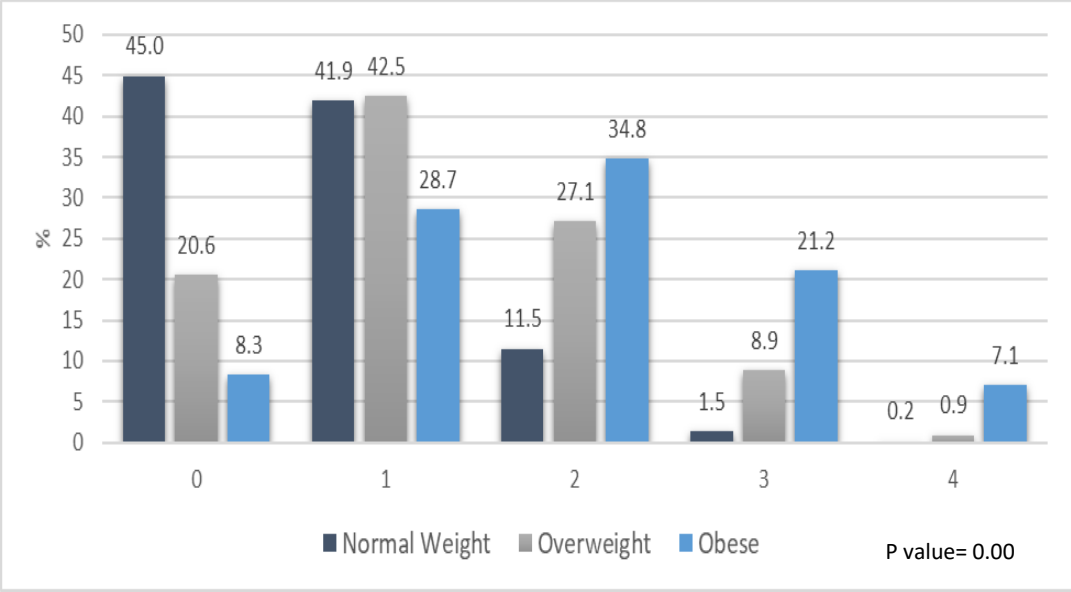

Figure 20: Number of accumulated cardiometabolic risk factors distribution by BMI status.

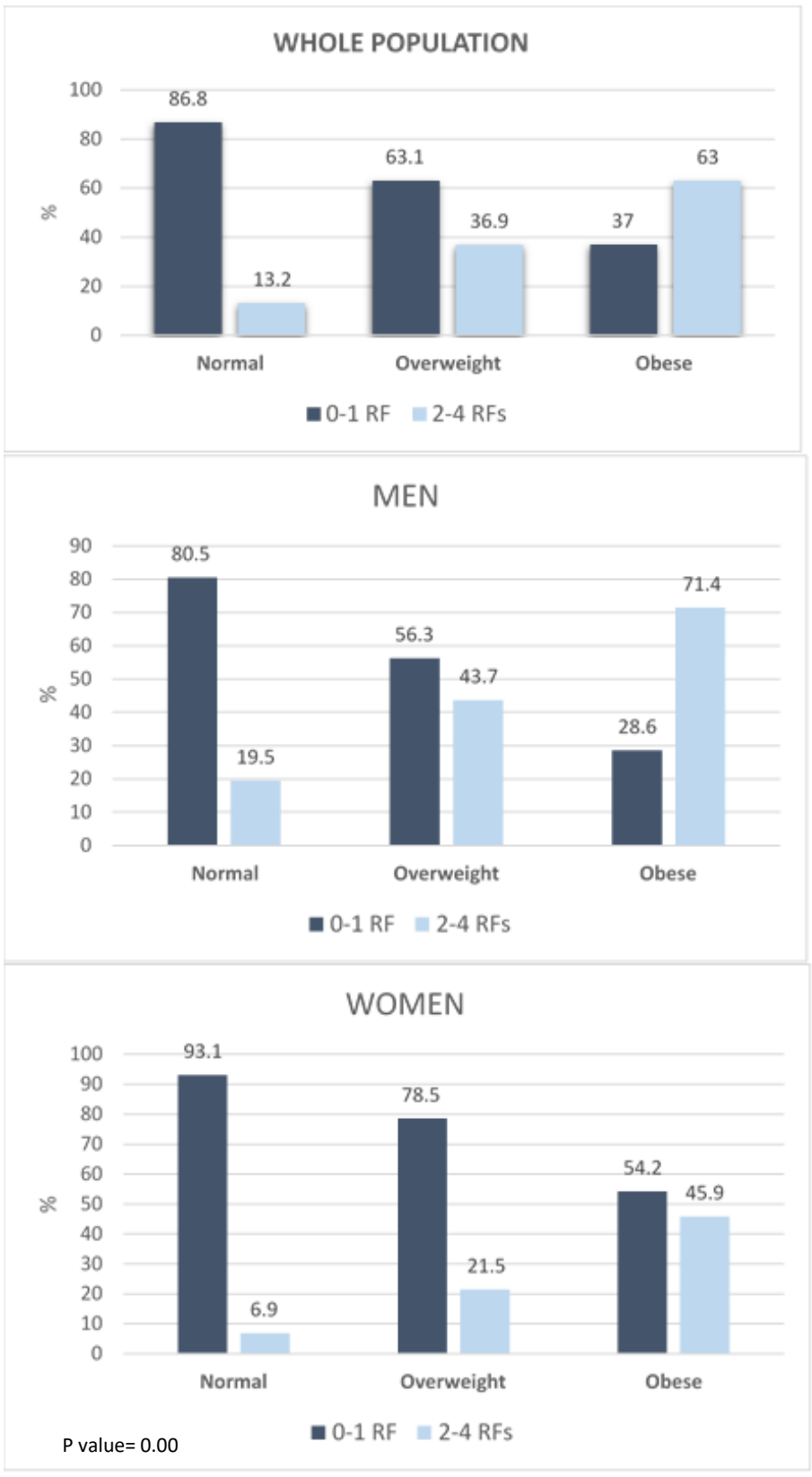

Figure 21: Burden of cardiometabolic risk factors by BMI status and Gender.

In unadjusted univariate logistic model, almost all social and behavioral determinants were significantly associated with accumulating of 2-4 cardiometabolic risk factors across BMI classes. However, in the forward-stepwise approach, it was shown that only age was significantly associated with the increased burden of cardiometabolic risk factors (Table 16). In men, age increased the odds of having 2-4 risk factors by 9% (OR 1.09 (1.05 – 1.15)) in the normal BMI group, and by 7% (OR 1.07 (1.03 – 1.11)) in the overweight. In women, age had a similar effect to that in men, where it increased the odds by 8 – 10% across the BMI classes; 1.08 (1.01 – 1.15) in the normal BMI, 1.10 (1.04 – 1.16) in the overweight and 1.08 (1.03 – 1.13) in the obese. Additionally, the effect of being employed showed a significant increase in the odds of having 2-4 risk factors in obese men only.

Table 16: Forward-stepwise association of having ≥2 cardiometabolic risk factors in BMI classes in men and women.

	BMI Classification		
	Normal	**Overweight**	**Obese**
	Adjusted OR (95% CI)	Adjusted OR (95% CI)	Adjusted OR (95% CI)
Men			
Age	1.09 (1.05 - 1.15)	1.07 (1.03 - 1.11)	
Employment			2.54 (1.5 – 4.3)
Women			
Age	1.08 (1.01 - 1.15)	1.10 (1.04 - 1.16)	1.08 (1.03 - 1.13)

Data is presented as Odd ratio (95% confidence interval). Gender reference group is males. Employment status reference group is being unemployed.

Chapter 6: Discussion

This thesis presents the first local comprehensive epidemiological description of the major cardiometabolic risk factors: obesity, dysglycemia, dyslipidemia, hypertension and central obesity, based on a large sample of young Emirati population. The thesis addressed the inter-relationship between the cardiometabolic risk factors and their clustering distribution. Furthermore, for the first time, it presents the effect of social factors, family history of NCDs and behavioral determinants on the prevalence of the cardiometabolic risk factors and their burden, and assesses the associations between these determinants and the cardiometabolic risk factors. Moreover, the study shows how the cardiometabolic risk factors are distributed across different BMI classes and how they are affected by other variables.

6.1 Objective 1: Describe the distribution of cardiometabolic risk factors in the population.

Obesity was present in 27.2% of the population. The age-adjusted prevalence rate was 26.5% (25.2 – 27.7). This rate was similar to prevalence rates reported locally, where the rates of obesity ranged from 25% to 35.4% in similar age groups (11, 17, 37, 81). In this study, obesity was higher in men than in women; 29.7% and 21.6%, respectively. This trend was similar to another nation-wide study published in 2012 (17). Moreover, obesity significantly increased with increasing age, in the whole study population and in each sex. The previous national survey showed similar trends across age groups (11). The age-standardized rate of obesity of 30% is quite alarming compared to that of the global rate of 12% (156).

The age-adjusted prevalence rates for diabetes was 3.5%, and for pre-diabetes rate was 8.2% in the whole study population. These rates were similar to the ones reported by the UAE national survey for the age group 18-44; diabetes had a

prevalence of 3.3% and prediabetes was 6.5% among Emiratis (11). The study findings showed that the age-adjusted prevalence of dysglycemia in this population was 11.7% and it was higher in males (14%) than in females (8.3%). Similarly, as shown with other cardiometabolic risk factors, the proportion of people with abnormal glycaemia increases with age. In this analysis, the rates of glycaemia doubled from the youngest age group (below 20 years) to the oldest age group (35 to 40 years). It was found that 7.6% of participants aged 18 and 19, and 8.3% of participants between 20 and 24 years had abnormal glycemic status. This supports the international connotation that prediabetes and diabetes are rapidly rising in the adolescents and young adults as reported by the Centre for Disease Control and Prevention (CDC) (59). Rates in UAE are very high; according to the IDF, the age-adjusted prevalence of diabetes was 16.3% in UAE, while it is 12.2% in the Middle East and North Africa (MENA) region in 2019 (61). The MENA region had the highest rate compared to other parts of the globe. A recent local analysis on 33,000 men revealed a relatively higher prediabetes prevalence of 33% in the 18-19 age group, and 40.2% in the 20-24 age group (37) based on fasting blood glucose measurements.

The differences in the methodological approaches could explain the difference prevalence of prediabetes reported in this thesis as only 20.8% of this population had fasting blood sample and therefore HbA1c was mainly used as a marker for diabetes and prediabetes. HbA1c is a validated and trusted tool to be used for diabetes classification (152). However, it raises some concerns when used to diagnose for prediabetes (157). Validation studies on HbA1c, for prediabetes, had been assessed against oral glucose tolerance test (OGTT) internationally. Depending on the defining criteria, HbA1c may capture only 50% of abnormal OGTT. Glycated hemoglobin is affected by ethnic, racial and gender differences. Although it has shown to

underestimate for prediabetes, its sensitivity and specificity still appears to be useful, convenient and reliable for both screening and diagnostic purposes (158, 159).

With the broad definition of dyslipidemia applied in this project, the results revealed that 61.7% of the whole population as having an abnormality in their lipid profiles. This high proportion of dyslipidemia might not be comparable to other local studies due to the difference in the definition criteria and methods of blood sampling; fasting or random (17, 37). Although, blood collection for lipid testing purposes are traditionally required to be fasting samples, dyslipidemia analyses were done using non-fasting blood samples in this study population. Recent reports show that random blood samples are acceptable (160, 161). Moreover, observational studies demonstrate that in comparison to fasting level, measurements only altered minimally, by 8 mg/dL or-0.2 mmol/L, when compared to fasting lipid levels. Nevertheless, when applying the Weqaya's definition of dyslipidemia in this sample population, dyslipidemia would account for 43.2%, which is comparable to the Weqaya finding within the 18-39 age group (17). Similarly, in another national report, abnormal total cholesterol levels were comparable in the same age group (18-29) (37). The global prevalence of dyslipidemia among adults was 39% in 2008 (82). This rate was found associated with the income of the country. The rates were doubled in high-income countries compared to low-income countries.

Elevated blood pressure was identified in 22.9% of the sample. It was shown that hypertension in men was 3-folds higher than in women, 30.9% versus 9.2%, respectively. Interestingly in men, hypertension was highest (30%) in the 20-24 age group, whereas in women, the rate was highest (25%) in the oldest age group; 35 – 40 years. These rates were comparable with other national studies for similar age groups. In all reports, men consistently had higher prevalence rate for hypertension than

women (11, 17). The Coronary Artery Risk Development in Young Adults (CARDIA) study in the US showed a similar trend in young adults (162); hypertension prevalence was 20% in the adults aged 18 to 30. A global prevalence of 26.4% was estimated among adults in year 2000 (163). In the age and gender breakdown, hypertension was reported in 12.7% among the 20-29 age group and 18.4% in the 30-39 age group in men. Men had double the rates of women in all age groups.

The prevalence of abdominal obesity in this study population was estimated as 24.3%, and males had a higher rate than women; 29.6% and 12.5%, respectively. However, these findings were lower than the Weqaya study, where the prevalence rates for abdominal obesity were 46.5% in men and 36.4% in women, aged 18-39 years (17). In a smaller local study on young women aged 18-25 years, high waist circumference was detected in 18.2% of the sample (38). In the US, the NHANES report of 2007-2010 estimated abdominal obesity in 18-39 age group as 38.7% (164).

It is well established that before heart disease or diabetes develops, multiple metabolic abnormalities co-exist. The clustering of the cardiometabolic risk factors showed interesting patterns in this study population. Dyslipidemia showed that it coexisted with another metabolic abnormality in more than 75% of the time, followed by obesity and central obesity. Hajat et al. presented that cardiometabolic comorbidity was most evident in diabetic participants (17). Most metabolic diseases co-existed with dyslipidemia, followed by obesity. The patterns were also similar across gender and age groups. However, since males had higher prevalence of some metabolic markers than females did, this was reflected in the comorbidity as well. Although the pattern was similar in all 3 age groups, as illustrated in Figure 12, comorbidity became more intense as age increased.

Moreover, when investigating the associations in between the cardiometabolic risk factors after the adjustment for each other, different associations between different pairs of cardiometabolic risk factors indicate that these risk factors cluster differently in people. Overall, obesity had the strongest relationship with all metabolic abnormalities. Baynouna et al. (165) showed that the strongest interrelationship between risk factors was detected with obesity; with hypertension, with an odd ratio 1.9 (1.2 – 3.0), and with high LDL, odd ratio 1.7 (1.1-2.5). To exclude collinearity between obesity and central obesity, correlation tests between BMI and waist-to-hip ratio were carried out. The estimated correlation was 0.42. Interestingly, among individuals that did not have central obesity, 18.5% were BMI-obese. As for those that did have central obesity, only 54% had BMI-obesity.

In men, the prevalence of obesity, dysglycemia and central obesity were higher in the married individuals, and among smokers. Interestingly, male students were more obese and with higher rate of lipid abnormalities than the employed and unemployed individuals. People with less than an undergraduate degree showed a higher prevalence of obesity and dyslipidemia. In women, being married or unemployed had higher prevalence rates of most risk factors. Having a low education had higher obesity. Among smokers, obesity was more prominent than non-smokers. For family history, the risk factors were found higher in those that had a family history of non-communicable diseases than those that did not have a family history in both men and women. There was no significant difference in the distribution of risk factors according to physical activity classes. This could be attributable to the low power, as only 45% of the population had valid physical activity data.

The findings showed that having a lower education attainment had consistently increased the odds of being obese. Similar to previous research, obesity was found to

be associated with being employed. A study by Veronesi found an association between employment and raised cardiometabolic risk factors (166). This association was explained by work-related stress, spending long hours sitting, long hours and shift work – all of these employment factors have been linked to increased obesity and other cardiovascular risk factors. Dysglycemia was found to be associated only with employment status in this analysis; being a student reduced the odds of having an abnormal glycemic status by 50–66 percent. Dyslipidemia was associated with smoking, being a student and having lower education. Central obesity was associated with behavioral risk factors, smoking and physical inactivity. Only one local previous study investigated the association of smoking with cardiometabolic risk factors (165), and found that smoking was associated with low HDL, which supports the study finding. A prospective-analysis published in 2017 identified the patterns of clustering of cardiovascular risk factors (167). It showed that low physical activity, lower education and family history of CVD had higher risk factors accumulation in men.

6.2 Objective 2: Describe the burden of cardiometabolic risk factors.

Overall, one quarter of the total sample population had no cardiometabolic risk factors. However, almost half (47.7%) of the male population in this study had two or more risk factors, while only 28% of the female's population did. Grouping the burden into two categories, 0-1 and 2-5 risk factors yielded a 60-40 ratio; 60% had one or no risk factor, and 40 had two or more risk factors. However, this should be considered as alarming findings bearing in mind that this was a young population sample with age range between 18-40. surprisingly, even 24% of the subjects in the youngest age group18-19 years were already having 2 or more cardiometabolic risk factors.

A recent report from the UAE National Health Survey estimated that 49.5% of the 18-44 years' population have three or more of the following risk factors: smoking,

inadequate diet, insufficient physical activity, overweight, or raised blood pressure (11). The survey results indicated that there were more men than women with such criteria (54.4% vs. 45.1% respectively). However, this estimation was not limited to Emiratis and included burden of non-metabolic risk factors. In another recent publication attempted to study the burden of cardiovascular risk factors in 33,000 young military men, it was estimated that 24% had at least 2 risk factors (37). This rate is probably underestimated as the sample subjects were military men, which have differences in age structure, social and behavioral characteristics.

This thesis investigated the associations between social and behavioral determinants and the accumulation of 2 or more cardiometabolic risk factors for the first time in the UAE. Aging had a consistent 10% increase in the odds of the accumulation in both males and females. It is well known that aging increases the risk for cardiovascular disease as there are multiple structural and functional alterations that occur throughout a lifespan (168). For instance, changes at the molecular level, such as the increase in oxidative stress can lead to obesity, diabetes, and frailty, which is called “cardiovascular aging”. Having a lower educational accomplishment increased the odds of accumulating cardiometabolic risk factors in the whole sample by 37%, and in women by 61%. Degano et al. (169) reported that people with primary or lower education had a 49% increase in the risk for CVD incidence. They also reported that education affected CVD by affecting hypertension, BMI and diabetes. Finally, having a family history of metabolic disease increased the odds up to 64%. These findings show the need to develop preventive strategies and screenings targeted for high-risk individuals with lower education and with family history of NCDs.

6.3 Objective 3: Investigate the effect of BMI on the other cardiometabolic risk factors and their burden.

The third phase of the project was designed to assess the burden of risk factors by the different BMI classes. The aim was to describe for the first time in the country, how each cardiometabolic risk factor and their accumulation might differ in people with normal BMI, overweight, and obese. The age-adjusted prevalence rates were substantially higher in the obese group compared to those of normal weight. For instance, the proportion of those with abnormal HbA1c increased in the obese group, 3.3-folds in men and by 7-folds in women. Abnormal fasting glucose was also seen to increase in the obese group, 1.6 folds in men and 4 folds in women. With regards to lipid markers, the rates doubled in the obese group compared to the normal weight group across both genders. The risk of hypertension was also elevated, 3.4 folds in men and 6.5 folds in women. Lastly, central obesity had a 4-fold and 5-fold increase in men and women, respectively.

Interestingly, the proportions with abnormal cardiometabolic markers were higher in the normal BMI group in the youngest age group below 20 years old, compared to the other BMI groups within the same age group. This was seen for increased glycated hemoglobin, fasting glucose, lipid markers, and blood pressure. This finding suggests that young people with normal weight are not protected from having other metabolic abnormalities. This suggests that being young and of normal BMI range does not necessarily indicate a metabolically healthy status. Moreover, the results suggest that with increasing BMI, the number of risk factors accumulate. This suggestion can be explained from the abdominal obesity perspective. For instance, having central obesity but normal BMI was shown to have increased odds of cardiovascular risk factors and accumulation (101). In another report, among 5000 individuals non-obese with normal-BMI, there was a significantly increased

prevalence of high blood pressure, high fasting glucose, and dyslipidemia (170). Their logistic regression analysis showed significantly increased odds in high blood pressure (OR = 1.53; 95% CI = 1.20–1.94), low HDL cholesterol (OR = 2.06; 95% CI = 1.09–3.89), and high trygliceride level (OR = 1.65; 95% CI = 1.27–2.16).

Although BMI does not differentiate between lean mass and fat mass (171), it was highly correlated with body fat percentage in this study (correlation= 0.74), Figure 22.

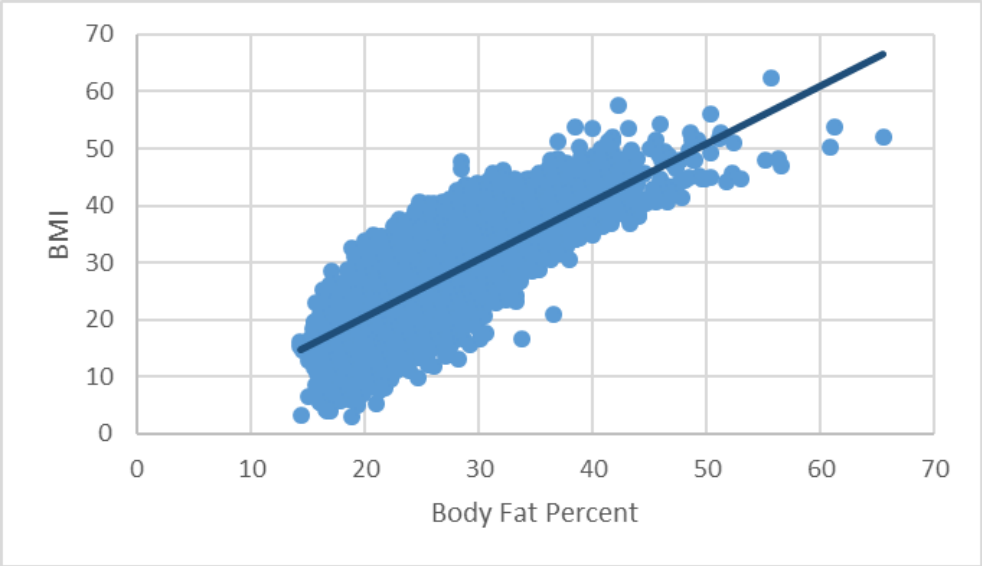

Figure 22: Body fat percent and BMI agreement

6.4 Metabolic Syndrome

Although the thesis addressed the burden of cardiometabolic risk factors based on predefined definitions, additional estimates of the rate of Metabolic Syndrome (MetS) using the ATP3 criteria were performed. The ATP3 criteria for identifying MetS is having 3 out of 5 metabolic abnormalities (172). The results are summarized in Table 17.

Table 17: Metabolic Syndrome in the sample.

Metabolic Syndrome using the ATP 3 definition.

Criteria: (3/5) of the following:

- Central obesity (Men > 102 cm, Women > 88 cm)
- Fasting Triglycerides (≥150 mg/dL) or taking lipid medication
- Fasting HDL cholesterol (Men <40 mg/dL, women <50 mg/dL) or taking lipid medication
- Fasting glucose ≥110 mg/dL or taking antidiabetic medication
- Blood pressure ≥130/≥85 mm Hg or taking blood pressure lowering medication

Results:

- Central obesity 1,015/4,819 (21.1%)
- High TG 189/1,127 (16.8%)
- Low HDL 449/1,129 (39.8%)
- High Blood Pressure 1,989/4,844 (41.1%)
- High glucose 117/1,108 (10.6%)

Metabolic Syndrome in the population (n=1,052) = 14.7%
Age-adjusted prevalence= 14.0% (11.8-16.1)

	Men (n=765)	**Women (n=287)**
Crude Metabolic Syndrome %	16.2%	10.8%
Age-adjusted %	15.8% (CI 13.2-18.4)	8.5% (CI 5.0-12.0)

Only few studies in UAE estimated metabolic syndrome. Two cross-sectional studies in 2008 estimated the prevalence in UAE nationals aged 20 to over 60. The rates estimated were 22.7% and 42.4% (40, 173). Another study on Emirati young women aged 17-25 years estimated the prevalence to be 6.8% (38).

This thesis's findings, along with the previously published results, show that metabolic syndrome rates are higher in UAE's young adults compared to the US young adults aged 20-40. The NHANES 3 estimated the prevalence of metabolic syndrome in this age group as 10.7%, their age-adjusted prevalence in the whole NHANES cohort, across all ages up to over 60 was 25.2% (174).

6.5 Strengths and Limitations

The principal strengths of this study include the large sample size of young Emiratis, and the extensive information collected. This study mainly focused on recruiting young adults, who are often underrepresented in other non-communicable disease studies. The thorough process collected various data points, from sociodemographic, to lifestyle behaviors, health and family history. All blood samples and physical measurements were collected in a standardized procedure to ensure consistent quality and reduce the risk of information bias. All of these data points allowed to employ detailed and specific disease-identification criteria.

Most epidemiological studies have the risk of having selection bias that can affect the external validity of the study. Selection bias is introduced at the individual/group selection level, where proper randomization is not achieved and therefore rendered unrepresentative of the population to be analyzed (175). The main weakness of this study is that it is based on voluntary recruitment of participants. This might introduce the risk of having selection bias and potentially affect the representativeness of the study sample. Another weakness observed is that more males (60%) were recruited than females (40%), and that they were recruited from different centers. The analysis of the results therefore varied and described separately for each gender. Moreover, it is essential to address a major limitation related to cross-sectional studies, which is the inability to identify a causal relationship between the potential risk factor and outcome. Therefore, the results of this study must be interpreted cautiously and inferred to the local populations of similar age and sociodemographic characteristics. Besides selection bias, that is attributable to the volunteer sample recruitment, this study must take into consideration potential information bias and confounding. Information bias is defined as any systematic difference from the truth

that arise in the data collection steps (176). Similar to other observational studies, this study is prone for measurements bias, recall bias and misclassification bias.

This study used a broad definition for dyslipidemia, which was based on 4 lipid markers, self-report and the use of lipid-lowering medication. This definition was recommended by the ATP 3 guidelines for persons above 20 years old (177). Random non-fasting samples were used for the analysis, which is unconventional to normal practice. Traditionally, blood collection for lipid testing purposes are required to be fasting samples. However, recent reports show that random blood samples are acceptable. Observational studies demonstrate that in comparison to fasting level, measurements only altered minimally, by 8 mg/dL or-0.2 mmol/L, when compared to fasting lipid levels (160, 161). So far, there is no hard-scientific evidence to why fasting samples are better than random samples when evaluating lipid profile for cardiovascular risk prediction. In fact, most studies now recommend non-fasting samples as they are easier to collect during the day and represent the normal postprandial state of individuals. Many countries are now changing their guidelines towards a consensus on measuring lipid profiles for cardiovascular risk prediction in the non-fasting state to simplify blood sampling for patients, laboratories, and clinicians worldwide (178).

The GPAQ, a self-reported questionnaire designed to estimate physical activity, has undergone validity programs that showed it is a valid and reliable tool, but also adaptable to incorporate cultural differences. It had been translated to many languages and therefore several validation studies were carried to show its validity and reliability in different countries and language settings. In UAE, there were no GPAQ validity studies yet. Researchers also use accelerometers and/or pedometers to collect physical activity data, which is the gold standard method for physical activity data

collection. Most studies conclude that GPAQ is an acceptable measure of physical activity, and the results ranged between fair-to-moderate validity in multiple languages (179, 180). There are no GPAQ validation studies performed in the UAE. One Saudi study designed to measure GPAQ validity against accelerometers. It concluded that GPAQ had a low agreement with the accelerometer but can be a reliable tool for estimating moderate to vigorous physical activity (181). However, when assessing sedentary behavior, GPAQ remains to poorly capture that information. Sedentary behavior is not synonymous with physical inactivity. An individual can be physically active and also having long hours of sedentary behavior (139). Therefore, it is important to address sedentary behavior independently from physical activity. The amount of missing data was also relatively high for some important measures like the physical activity, which was 55%. This may have been the reason for the lack of association between physical inactivity and metabolic outcomes.

Confounding, also called “mixing of effects”, refers to the exposure’s effect on a specific outcome is mixed with other additional factor/ or set of factors that leads to a distortion of the true relationship (182). Confounding factors can mask the true association between an exposure and outcome, which in turns makes it difficult to find a clear causal link. An important characteristic of a confounder is that it is related to both the exposure and outcome, without being an intermediate factor in the pathway from exposure to outcome. To deal with known confounders, is to adjust for them in a multivariate model. In this study, the available confounder were adjusted for, as mentioned in the methods section. Nevertheless, the lack of dietary data, which is another important behavioral risk factor that is known to affect cardiometabolic health, was also another limiting factor to the study. Overall, it is not possible to measure and

report all confounders, therefore, there always be residual confounders; which are factors that cannot be measured or are unknown.

Chapter 7: Conclusion and Recommendations

This thorough research on cardiometabolic risk factors provided novel and rich information about the cardiovascular risk in young adults of the United Arab Emirates, which present the majority age demographic of the country. This study confirmed that the prevalence of obesity, dysglycemia, dyslipidemia, hypertension and central obesity are alarmingly high. The study introduced how social and behavioral characteristics play a role in the cardiometabolic risk factors distribution and how these cardiometabolic risk factors co-exist and interplay with one another. For the first time in UAE, this thesis investigated the accumulation – or burden – of cardiometabolic risk factor in young adults and how the accumulation is affected by other variables. Moreover, it assessed the relationship of different BMI classes on the risk factors distribution and clustering.

7.1 Recommendations

Addressing the alarming prevalence of cardiometabolic risk factors and their accumulation from a young age calls for taking measures to control them. Understanding that some social groups are more prone for having a metabolic abnormality can help design specific prevention measures towards them. For instance, this research found that employed men had higher rates of cardiometabolic risk factors, as well as, employment increased the risk for having a higher burden. This finding can inspire to design special screening and awareness campaigns as well as interventional campaigns for men at the workplace.

Comorbidity analysis in this study showed that dyslipidemia is almost always simultaneously co-exist with other cardiometabolic abnormalities. This sheds a light on people that are diagnosed with dyslipidemia. Such patients must be additionally

screened more often for other risk factors and must be made aware that they would be more prone for having another metabolic abnormality.

Another alarming finding was that young adults below the age of 20 years have already accumulated multiple risk factors. It was shown also that although the majority of this age group had normal BMI, some had higher proportions of abnormal markers, when compared with those that were overweight and obese. Proving that normal-weight young adults are not immune to cardiovascular risk must be translated into intense preventive and screening programs across universities and schools.

Finally, in line with personalized medicine, there will be a need for designing personalized cardiovascular prevention strategies. Personalized management of CVD is defined as the selection of the best treatment for an individual patient. Individualized recommendations must consider all factors available at hand. It could include the genetic and epigenetic predisposition, choosing individual-specific treatment course for cardiometabolic abnormalities, as well as, surgery, lifestyle modifications and/or combinations. Application of the personalized medicine principles can enhance the quality of life for patients at high risk for CVD.

7.2 Further research

The findings of this study provide a platform for further research. Further research of other sociodemographic and behavioral factors and how they can affect cardiovascular health in this population is recommended. The differences between rural and urban living settings is an understudied subject in terms of health in UAE. Furthermore, novel socio-behavioral factors like sleep patterns and mental status and how they can affect the epidemiology of cardiometabolic risk factors and eventually non-communicable disease are being studied globally and should be studied in the UAE. Studying how family history affected the distribution and odds of

cardiometabolic risk factors can pave the pathway for genetic analysis and contribution in disease advancement. It is important to quantify the effect of genetic predisposition to cardiovascular disease, and essential to study the genetic – lifestyle interactions.

Finally, addressing the heavy burden of risk factors is only a first step to understand how clustering will affect the incidence of cardiovascular disease. Understanding how clustering manifests, and which cardiometabolic abnormality precedes the other, will offer a novel way to design target-group-specific measures for the prevention of NCD development. The UAE Healthy Future Study is designed as a longitudinal study. Such design is necessary to quantify the risk of cardiometabolic outcomes. Advancing in this direction will have the potential to develop and design risk score calculators for cardiovascular risk prediction that is appropriate for this population.

7.3 UAE actions towards NCDs

The UAE is responding to the alarming rates of metabolic abnormalities by setting political commitment to NCDs from the top leadership in the country to different governments and structures. Providing world-class healthcare is one of the six pillars of the UAE National Agenda in line with Vision 2021. The pillar titled “long and healthy lives” emphasizes the importance of prevention medicine in reducing the risk of NCDs. This is reflected in a number of federal government strategies to measure rates of disease and to develop health promotional programs, including setting quantifiable methods to measure the country’s performance against its targets for 2021. NCDs related measures includes number of deaths from cardiovascular diseases and cancers per 100,000 and prevalence of diabetes. Other measures include the prevalence of smoking any tobacco product. The National Strategy for Prevention and Control of NCDs 2017-2021 was introduced by the

Ministry of Health and Prevention in line with WHO EMRO regional action plan. The strategy aims to promote the practice of healthy lifestyle for the UAE community and provide comprehensive and integrated healthcare in innovative and sustainable ways to ensure the prevention of diseases. The ministry of health has begun to implement many of the activities as listed in the national NCD action plan (2017-2021) and UAE national agenda for 2021 (183, 184). A National NCDs committee was established in 2017 and contains representatives from across government. Prominent progress is made concerning policies for NCDs prevention and control, such as the recent tobacco taxation (100%) and recent taxes implemented on soft drinks (50%) and power drinks (100%). The UAE cabinet adopted a decision to expand the list of excise products to include sweetened beverages, sugary drinks and electronic smoking devices, starting January 1, 2020 (184). Additionally, there are several initiatives to increase physical activity by the Sport Authority, including the "30X30 challenge" and other similar initiatives to mainstream physical activity.

Recognizing the huge public health impact of NCDs and common risk factors, the UAE government has shown remarkable commitment and leadership by investing in preventive measures. Other initiatives include 2021 Healthy Children initiative, Junior Chef Program, and Implementation and development of policies to improve access to nutritious and healthy food.

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Appendices

Appendix 1: The UAE Healthy Future Study Questionnaire

Section 1: Demographic data

Q. No	Stem	Responses / Categorical Label
D1	Gender	01 Male 02 Female
D2	Marital Status	01 Single 02 Married 03 Divorced/ separated 04 Widow/Widower
D3A	Emirate / city of residence	01 Abu Dhabi 02 Al Ain 03 Dubai 04 Sharjah 05 Ajman 06 Um Al Quwain 07 07 Ras Al Khaima 08 Fujairah
D3B	Area of residence	Select one from List of areas NN None of above UN Do not know DA Prefer not to answer
D4A	How many houses do you own? (include farm house, Island house, beach house, house in different Emirate, house in different country)	Enter number OR UN Do not know OR DA Prefer not to answer
D5	Do you or your family own or rent the primary housing that you live in?	Select one from - 01 Own outright (by you or someone in your household) - 02 Own with a mortgage - 03 Rent - 04 Live in accomadation rent free / government granted housing - NN None of the above - DA Prefer not to answer
D7	Including yourself, how many people are living together in your primary household? (Include those who usually live in the house such as students living away from home during term) Do not include people working in your household	Enter number OR UN Do not know OR DA Prefer not to answer
D7A	How are the other people who live with you related to you? (You can select more than one answer)	Select from - 01 Husband or wife - 02 Son and/or daughter (include step- children) - 03 Brother and/or sister - 04 Mother and/or father - 05 Grandparent - 06 Grandchild - 07 Other related - 08 Other unrelated - DA Prefer not to answer
Q. No	Stem	Responses / Categorical Label
D7B	How many people are working in your primary household? (Please include drivers, housemaids, cooks, farmers, etc.)	Enter number OR UN Do not know OR DA Prefer not to answer
D7C	How many rooms are there in your house (not including kitchens and bathrooms)?	Enter number OR UN Do not know OR DA Prefer not to answer
D8	How many cars or vans are owned, or available for use, by you or members of your household? (please include company vehicles if available for private use)	Enter number OR UN Do not know OR DA Prefer not to answer
D10	What is the total monthly income received by your HOUSEHOLD in AED?	Select one from - 01 Less than 20,000 - 02 20,000 to 39,999

		- 03 40,000 to 59,999 - 04 60,000 to 79,999 - 05 80,000 to 99,000 - 06 100,000 to 119,000 - 07 Greater than 120,000 - UN Do not know - DA Prefer not to answer
D10A	How many times a year do you travel overseas for a holiday?	Enter number OR UN Do not know OR DA Prefer not to answer
D9	Which of the following describes your current situation? (You can select more than one answer)	Select from - 01 In paid employment, - 02 Self-employed (e.g. consultant) - 03 Business man / business women - 04 Employer - 05 Retired - 06 House wife - 07 Unable to work because of sickness or disability - 08 Unemployed - 09 Doing unpaid or voluntary work - 10 Full or part-time student - NN None of the above - DA Prefer not to answer
D9A1	Which of the following describes your occupation?	Select from: - 01 Manager - 02 Professional - 03 Technician or Associate professional - 04 Clerical support worker - 05 Service or sales worker - 06 Agricultural, forestry or fishery worker - 07 Craft or related trades - 08 Plant or machine operator - 09 Elementary occupation - NN None of the above - DA Prefer not to answer
D9A	In a typical WEEK, how many hours do you spend at work? (Do not include hours travelling to and from work)	Enter number OR UN Do not know OR DA Prefer not to answer
Q. No	Stem	Responses / Categorical Label
D9E	What level of activity is involved in your main occupation?	Select one from - 01 Sitting most of the time - 02 Standing most of the time - 03 Walking most of the time - 04 Sitting, standing, and walking in equal amounts - 05 Other work with moderate physical activity (includes moving or lifting objects of moderate weight) - 06 Physically heavy work (includes moving or lifting heavy objects or activities) - UN Do not know - DA Prefer not to answer
D9F	Does your work involve shift work?	Select one from - 01 Never/rarely - 02 Sometimes - 03 Usually - 04 Always - UN Do not know - DA Prefer not to answer
D9DA	Does your job involve working during the night?	Select one from - 01 Never/rarely - 02 Sometimes

		- 03 Usually - 04 Always - UN Do not know - DA Prefer not to answer
D10	For how many years have you not been working?	- One or less - More than one year ago - Never worked before - Prefer not to answer
D11	What is the highest level of education that you have completed?	Select from - 01 Did not attend or complete primary school - 02 Primary school - 03 Middle school - 03 Secondary school - 04 University - 05 Postgraduate degree (e.g Masters or PhD) - NN None of the above - DA Prefer not to answer
D12	How old were when you/your family first owned your own house?	Enter number OR Select one from - 01From birth. - 02 We live in rented accommodation - UN Do not know - DA Prefer not to answer
D12A	How old were you when your house first had an indoor toilet?	Enter number OR Select one from - 01 From birth. - 02 We don't have an indoor toilet - UN Do not know - DA Prefer not to answer
Q. No	Stem	Responses / Categorical Label
D12B	How old were you when your house first had Air Conditioning?	Enter number OR Select one from - 01 From birth. - 02 We don't have AC - UN Do not know - DA Prefer not to answer
D12C	How old were you when your household first had a car?	Enter number OR Select one from - 01 From birth. - 02 We don't have a car - UN Do not know - DA Prefer not to answer
D12D	How old were you when your household first had a housemaid /cook / driver/ gardener?	Enter number OR Select one from - 01 From birth. - 02 We don't have a housemaid/ cook/ driver / gardener - UN Do not know - DA Prefer not to answer -
Q. No	Stem	Responses
D13	Where did you and your family live at around the time:	
D13A	Of your birth	Select one from - 01 City - 02 Village - 03 Desert (bedouin) - 04 Island - 05 Other - UN Do not know - DA Prefer not to answer
D13C	When you were 18 years old	Select one from

		- 01 City - 02 Village - 03 Desert (bedouin) - 04 Island - 05 Other - UN Do not know - DA Prefer not to answer
	Now	Select one from - 01 City - 02 Village - 03 Desert (bedouin) - 04 Island - 05 Other - UN Do not know DA Prefer not to answer
Q. No	Stem	Responses / Categorical Label
D14	In what type of housing did you live at around the time:	
D14A	Of your birth	Select one from - 01 Villa - 02 Apartment - 03 Shabiyah - 04 Other - UN Do not know - DA Prefer not to answer
D14C	When you were 18 years old	Select one from - 01 Villa - 02 Apartment - 03 Shabiyah - 04 Other - UN Do not know - DA Prefer not to answer
	Now	Select one from - 01 Villa - 02 Apartment - 03 Shabiyah - 04 Other - UN Do not know DA Prefer not to answer
D15	In a typical week, on how many days is incense burned in your home?	- Never - One day per week or less - Frequently (2 -5 days per week) - Almost every day (6-7 days per week) - UN Do not know - DA Prefer not to answer

Section 2: Physical Activity, sleep and smoking

Physical Activity		
Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person. Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food, seeking employment. *[Insert other examples if needed].* In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.		
Questions		Response
Activity at work		
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 4*
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days ⌊__⌋
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes ⌊__⌋:⌊__⌋ Hrs mins
4	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 7*
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days ⌊__⌋
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes ⌊__⌋:⌊__⌋ hrs mins
Travel to and from places		
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed]		
7	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 *If No, go to P 10*
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days ⌊__⌋
9	How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes ⌊__⌋:⌊__⌋ hrs mins
Recreational activities		
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure), [insert relevant terms].		
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 13*

11	In a typical week, on how many days do you do vigorous- intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊__⌋
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Physical Activity (recreational activities) contd.		
Questions		Response
13	Do you do any moderate-intensity sports, fitness or recreational *(leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking,(*cycling, swimming, volleyball*)for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P16*
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊__⌋
15	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs mins

Sedentary behaviour		
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*		
16	How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes ⌊__⌋⌊__⌋ : ⌊__⌋⌊__⌋ hrs min s

WP11	How often do you visit friends or family or have them visit you?	Select one from - 01 Almost daily - 02 2-4 times a week - 03 About once a week - 04 About once a month - 05 Once every few months - 06 Never or almost never - 07 No friends/family outside household - UN Do not know - DA Prefer not to answer
WP12	Which of the following do you attend once a week or more often? (You can select more than one)	Select from - 01 Sports club or gym - 02 Mosque - 03 Adult education class - 04 Family development foundation - 05 Other group activity - NN None of the above - DA Prefer not to answer
WP12A	In a typical DAY in summer, how many hours do you spend outdoors and are exposed to the sun?	Enter number OR FR Less than an hour a day OR UN Do not know OR DA Prefer not to answer

WP12B	In a typical DAY in winter, how many hours do you spend outdoors and are exposed to the sun?	Enter number OR FR Less than an hour a day OR UN Do not know OR DA Prefer not to answer
WP5	In a typical DAY, how many hours do you spend watching TV or using a computer, tablet, smartphone(do not include using a computer at work; put 0 if you do not spend any time doing it)?	Enter number OR FR Less than an hour a day OR UN Do not know OR DA Prefer not to answer
WP7	In a typical DAY, how many hours do you spend driving?	Enter number OR FR Less than an hour a day OR UN Do not know OR DA Prefer not to answer

SL1	About how many hours sleep do you get in every 24 hours? (please include naps)	Enter number OR UN Do not know OR DA Prefer not to answer

SL1A	On an average day, how easy do you find getting up in the morning?	Select one from - 01 Not at all easy - 02 Not very easy - 03 Fairly easy - 04 Very easy - UN Do not know - DA Prefer not to answer
SL1B	Do you have a nap during the day?	Select one from - 01 Never/Rarely - 02 Sometimes - 03 Usually - DA Prefer not to answer
SL2	Do you have trouble falling asleep at night or do you wake up in the middle of the night?	Select one from - 01 Never/Rarely - 02 Sometimes - 03 Usually - DA Prefer not to answer
SL4	Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?	Select one from - 01Yes - 02 No - UN Do not know - DA Prefer not to answer
SL5	Do you often feel tired, fatigued or sleepy during daytime?	Select one from - 01Yes - 02 No - UN Do not know - DA Prefer not to answer
SL6	Has anyone observed you stopping breathing during your sleep?	Select one from - 01Yes - 02 No - UN Do not know - DA Prefer not to answer

Q. No	Stem	Responses
INTRO 4	Now, some questions about smoking and tobacco use.. Press 'next' to continue.	Only one selection - Next
FR87225	We will begin by asking you about your use of cigarettes. On average, how often do you smoke cigarettes? If response=5, 8 or 9, go to FR87501. If response=1-4, go to BI87345.	1 Daily 2 Less than daily, but at least once a week 3 Less than weekly, but at least once a month 4 Less than monthly 5 Not at all 8 Refused 9 Don't know
FR87501	Have you ever smoked cigarettes, even one time?	1 Yes 2 No 8 Refused 9 Don't know
BI87345	Have you smoked 100 or more cigarettes over your lifetime? *100 cigarettes= 5 packs of 20 cigarettes OR 4 packs of 25 cigarettes.*	1 Yes 2 No 8 Refused 9 Don't know
FR87216	On average, how many whole cigarettes do you smoke per day? (1 pack typically contains 20 cigarettes.)	*Enter number of cigarettes.* 88 Refused 99 Don't know

FR87226	On average, how many whole cigarettes do you smoke per	*001 001* *002 002*

	week? (1 pack typically contains 20 cigarettes.)	*003 003* *...* *100 100* *101 More than 100* *888 Refused* *999 Don't Know* *Enter number of cigarettes.* *(Program values of range 1 - 100 with additional text response of 'More than 100'.)*
FR87201	During of the past 30 days, on how many days did you smoke cigarettes?	*Enter number of days. (Range 00-30)* 88 Refused 99 Don't know
FR87202	On average, on days that you smoked cigarettes, about how many cigarettes did you smoke per day? (1 pack typically contains 20 cigarettes.)	*Enter number of cigarettes or choose one of the coded responses.* 88 Refused 99 Don't know
FR87118	How old were you when you first tried cigarette smoking, even one or two puffs?	88 Refused 99 Don't know
FR87510 (Prev. NW87500)	Ask if (FR87225=2-4) or (FR87501=1). At the time when you were smoking cigarettes most often, how often did you smoke them?	1 Daily or almost daily; most days 2 Less than daily, but at least once a week 3 Less than weekly, but at least once a month 4 Less than monthly 5 Not at all 8 Refused 9 Don't know
FR87116 (Prev. NW87501)	Ask if FR87510=1 or FR87225=1. How old were you when you first started smoking cigarettes on most days?	88 Refused 99 Don't know *(Range 1 - 87)*
FR87131 (Prev. NW87502)	Ask if FR87510=1. During the time when you smoked cigarettes most days, on average, how many cigarettes did you smoke each day?	001 001 002 002 003 003 … 100 100 101 More than 100 88 Refused 99 Don't know *Enter number of cigarettes.* *(Program values of range 1 - 100 with additional text response of 'More than 100'.)*
FR87127 (Prev. NW87503)	Ask if FR87510=1. How old were you when you last smoked cigarettes on most days?	88 Refused 99 Don't know *(Range 1 - 87)*

MK87226	Ask all. We are now going to ask you about your use of midwakh/dokha. On average, how often do you smoke midwakh/dokha?	1 Daily 2 Less than daily, but at least once a week 3 Less than weekly, but at least once a month 4 Less than monthly 5 Not at all 8 Refused 9 Don't know
MK87501	Have you ever smoked midwakh/dokha, even one time?	1 Yes 2 No

		8 Refused 9 Don't know
MK87201	How many times have you smoked midwakh/dokha in your entire life?	1 Two or fewer 2 3-10 times 3 11-20 times 4 21-50 times 5 51-99 times 6 100 or more 8 Refused 9 Don't know
MK87217	On average, how many times do you smoke midwakh/dokha each day?	88 Refused 99 Don't know
MK87216	On average, how many times do you smoke midwakh/dokha each week?	88 Refused 99 Don't know
MK87241	During the past 30 days, on how many days did you smoke midwakh/dokha?	88 Refused 99 Don't know *Enter number of days. (Range 00-30)*
MK87242	Ask if MK87241=1-30. On average, on days that you smoked midwakh/dokha, about how many times did you smoke it per day?	88 Refused 99 Don't know
MK87518	How old were you when you first tried smoking midwakh/dokha, even one or two puffs?	88 Refused 99 Don't know
MK87535 (Prev. NW87505)	Ask if (FR87225=2-4) or (FR87501=1). At the time when you were smoking midwakh/dokha most often, how often did you smoke them?	1 Daily or almost daily; most days 2 Less than daily, but at least once a week 3 Less than weekly, but at least once a month 4 Less than monthly 5 Not at all 8 Refused 9 Don't know

MK87519 (Prev. NW87506)	Ask if FR87510=1 or FR87225=1. How old were you when you first started smoking midwakh/dokha on most days?	88 Refused 99 Don't know *(Range 1 - 87)*
MK87530 (Prev. NW87507)	Ask if FR87510=1. During the time when you smoked midwakh/dokha most days, on average, how many cigarettes did you smoke each day?	001 001 002 002 003 003 … 100 100 101 More than 100 88 Refused 99 Don't know *Enter number of cigarettes.* *(Program values of range 1 - 100 with additional text response of 'More than 100'.)*
MK87532 (Prev. NW87508)	Ask if FR87510=1. How old were you when you last smoked midwakh/dokha on most days?	88 Refused 99 Don't know *(Range 1 - 87)*
HK87209	Ask all. We are now going to ask you about your use of shisha (also known as waterpipe, hookah, narghile). Do you smoke shisha…?	1 Mainly on your own 2 Mainly shared with others 3 Alone and shared, about equally 4 Not at all 8 Refused 9 Don't know
HK87226	Ask if HK87209=1, 2 or 3. On average, how often do you smoke shisha (on your own or in a shared session with others)?	1 Daily or almost daily; most days 2 Less than daily, but at least once a week 3 Less than weekly, but at least once a month 4 Less than monthly 5 Not at all 8 Refused 9 Don't know
NC87802	Have you ever smoked shisha, even one time?	1 Yes 2 No 8 Refused 9 Don't know
NC87807	How many times have you smoked shisha in your entire life?	Two or fewer 2 3- 10 times 3 11-20 times 4 21-50 times 5 51-99 times 6 100 or more Refused Don't know
HK87217	On average, how many times per day do you smoke shisha?	88 Refused 99 Don't know *(Range 1 - 50)*

HK87216	On average, how many times per week do you smoke shisha?	001 001 002 002 003 003 … 100 100 101 More than 100 888 Refused 999 Don't Know *(Program values of range 1 - 100 with additional text response of 'More than 100'.)*
NC87822	During the past 30 days, on how many days did you smoke shisha?	88 Refused 99 Don't know *Enter number of days. (Range 00-30)*
NC87823	On average, on days that you smoked shisha, about how many times per day did you do that?	88 Refused 99 Don't know *(Range 1 - 50)*
HK87266	On average, each time you smoke shisha, how many shisha heads do you smoke?	88 Refused 99 Don't know *(Range 1 - 50)*
HK8726	How many shisha heads per week do you usually smoke?	001 001

8		002 002 003 003 … 100 100 101 More than 100 888 Refused 999 Don't Know *(Program values of range 1 - 100 with additional text response of 'More than 100'.)*
HK87744	On average, of those times you smoke shisha, how often does your shisha contain tobacco?	1 Never 2 Less than half the time 3 Half the time 4 More than half the time, but not always 5 Always 8 Refused 9 Don't know
HK87732	Where do you most often smoke shisha?	1 At home 2 Coffee shop 3 Bar/ club 4 Restaurant 5 Other, specify 8 Refused 9 Don't know
HK87732o	Specify other location:	88 Refused 99 Don't know
NC87810	How old were you when you first tried smoking ANY shisha (includes any shisha that was smoked on your own or shared), even one or two puffs?	88 Refused 99 Don't know *(Range 1 - 87)*

HK87535 (Prev. NW87511)	At the time when you were smoking shisha most often, how often did you smoke it?	1 Daily or almost daily; most days 2 Less than daily, but at least once a week 3 Less than weekly, but at least once a month 4 Less than monthly 5 Not at all 8 Refused 9 Don't know
HK87519 (Prev. NW87512)	How old were you when you first started smoking shisha on most days?	88 Refused 99 Don't know *(Range 1 - 87)*
HK87530 (Prev. NW87513)	During the time when you smoked shisha on most days, on average, how many times a day did you smoke it?	88 Refused 99 Don't know *(Range 1 - 50)*
HK87532 (Prev. NW87514)	How old were you when you last smoked shisha on most days?	88 Refused 99 Don't know *(Range 1 - 87)*
ET87091	Ask all. Thinking about INSIDE YOUR HOME… Over the last 7 days, for how many hours were you exposed to other people's TOBACCO smoke, including smoke from cigarettes, midwakh, or shisha?	Enter number 88 Refused 99 Don't know
ET87092	Ask all. Thinking about INDOOR PUBLIC PLACES… Over the last 7 days, for how many hours were you exposed to other people's TOBACCO smoke, including smoke from cigarettes, midwakh, or shisha? (e.g. in school, shops, restaurants, shopping malls, movie theaters.)	Enter number 88 Refused 99 Don't know

ET87093	Ask all. Thinking about OUTDOOR PUBLIC PLACES… Over the last 7 days, for how many hours were you exposed to other people's TOBACCO smoke, including smoke from cigarettes, midwakh, or shisha? (e.g. at playgrounds, sidewalks, entrances to buildings, parks, beaches.)	Enter number 88 Refused 99 Don't know
SL87210	Ask all. Do you use any tobacco that is not smoked?	1 Yes, chewing tobacco 2 Yes, Naswar 3 Yes, other 4 No 8 Refused 9 Don't know

Section 3: Family history and early exposures

Q. No	Stem	Responses
INTRO 5	Now, some questions about you and your family. Press 'next' to continue.	Only one selection - Next
Y1	In which country were you born?	Select one from 1. United Arab Emirates 2. Other UN Do not know DA Prefer not to answer
Y2	What year did you first come to live in the United Arab Emirates?	Enter number OR UN Do not know OR DA Prefer not to answer
Y2A	What was your birth weight (in kg)?	Weight in kilograms 999 Do not know 888 Prefer not to answer
Y3	Were you breastfed when you were a baby?	Select one from - 01 Yes - 00 No - UN Do not know - DA Prefer not to answer
Y3A	How many months were you breastfed when you were a baby?	Enter number OR UN Do not know OR DA Prefer not to answer
Y4	When you were 10 years old, compared to average would you describe yourself as:	Select one from - 01 Thinner - 02 Plumper - 03 About average - UN Do not know - DA Prefer not to answer

Y5	When you were 10 years old, compared to average would you describe yourself as:	Select one from - 01 Shorter - 02 Taller - 03 About average - UN Do not know - DA Prefer not to answer
Y6	Approximately how much did you weigh (in Kilograms) when you were 18 years old?	- Weight in kilograms - Do not know - Prefer not to answer
Q. No	Stem	Responses
Y7	Did your mother smoke regularly around the time when you were born?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
Y8	Did your father smoke regularly around the time when you were born?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
Y13D	Does/did your father ever suffer from? (You can select more than one answer)	Select from - HE Heart disease - ST Stroke - BP High blood pressure - DB Diabetes - OB Obesity - CH High cholesterol - NN None of the above - UN Do not know - DA Prefer not to answer
Y16D	Has/did your mother ever suffer from? (You can select more than one answer)	Select from - HE Heart disease - ST Stroke - BP High blood pressure - DB Diabetes - OB Obesity - CH High cholesterol NN None of the above - UN Do not know - DA Prefer not to answer
Y18	How many siblings do you have? (Please include those who have died. Do not include half-sisters, step-sisters or adopted sisters)	Enter number OR UN Do not know OR DA Prefer not to answer
Y19	Have any of your brothers or sisters suffered from any of the following illnesses? (You can select more than one answer)	Select from - HE Heart disease - ST Stroke - BP High blood pressure - DB Diabetes - OB Obesity - CH High cholesterol NN None of the above - UN Do not know - DA Prefer not to answer
Y23	Before their marriage, what was the family relationship between your father and your mother?	Select from 00 None 01 First cousin 02 Second cousin 03 Less than second cousin UN Do not

		know DA Prefer not to answer
Y24	How old were you when you got married?	- Age - Do not remember - Prefer not to answer

Section 4: Psychological health

Q. No	Stem	Responses
INTRO 5	Now, some questions about you and your family. Press 'next' to continue.	Only one selection - Next
Y1	In which country were you born?	Select one from 3. United Arab Emirates
Q. No	Stem	Responses
		4. Other UN Do not know DA Prefer not to answer
Y2	What year did you first come to live in the United Arab Emirates?	Enter number OR UN Do not know OR DA Prefer not to answer
Y2A	What was your birth weight (in kg)?	Weight in kilograms 999 Do not know 888 Prefer not to answer
Y3	Were you breastfed when you were a baby?	Select one from - 01 Yes - 00 No - UN Do not know - DA Prefer not to answer
Y3A	How many months were you breastfed when you were a baby?	Enter number OR UN Do not know OR DA Prefer not to answer
Y4	When you were 10 years old, compared to average would you describe yourself as:	Select one from - 01 Thinner - 02 Plumper - 03 About average - UN Do not know - DA Prefer not to answer
Y5	When you were 10 years old, compared to average would you describe yourself as:	Select one from - 01 Shorter - 02 Taller - 03 About average - UN Do not know - DA Prefer not to answer
Y6	Approximately how much did you weigh (in Kilograms) when you were 18 years old?	- Weight in kilograms - Do not know - Prefer not to answer

Y7	Did your mother smoke regularly around the time when you were born?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
Y8	Did your father smoke regularly around the time when you were born?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
Y13D	Does/did your father ever suffer from? (You can select more than one answer)	Select from - HE Heart disease - ST Stroke - BP High blood pressure - DB Diabetes - OB Obesity - CH High cholesterol - NN None of the above - UN Do not know - DA Prefer not to answer

Q. No	Stem	Responses
Y16D	Has/did your mother ever suffer from? (You can select more than one answer)	Select from - HE Heart disease - ST Stroke - BP High blood pressure - DB Diabetes - OB Obesity - CH High cholesterol NN None of the above - UN Do not know - DA Prefer not to answer
Y18	How many siblings do you have? (Please include those who have died. Do not include half-sisters, step-sisters or adopted sisters)	Enter number OR UN Do not know OR DA Prefer not to answer
Y19	Have any of your brothers or sisters suffered from any of the following illnesses? (You can select more than one answer)	Select from - HE Heart disease - ST Stroke - BP High blood pressure - DB Diabetes - OB Obesity - CH High cholesterol NN None of the above - UN Do not know - DA Prefer not to answer
Y23	Before their marriage, what was the family relationship between your father and your mother?	Select from 00 None 01 First cousin 02 Second cousin 03 Less than second cousin UN Do not know DA Prefer not to answer
Y24	How old were you when you got married?	- Age - Do not remember - Prefer not to answer

Section 5: General health

Q. No	Stem	Responses
INTRO8	Now some questions about your health. Please Press 'next' to continue.	Only one selection - Next
H1	In general how would you rate your overall health now ?	Select one from - 01 Excellent - 02 Good - 03 Fair - 04 Poor - UN Do not know - DA Prefer not to answer
H1A	In general, how was your health in childhood (less than 10 years old)?	Select one from - 01 Excellent - 02 Good - 03 Fair - 04 Poor - UN Do not know - DA Prefer not to answer
H2	Do you have any of the following? (You can select more than one answer)	Select from - 01 Mouth ulcers - 02 Painful gums - 03 Bleeding gums - 04 Loose teeth - 05 Toothache - 06 Dentures - NN None of the above - DA Prefer not to answer
H2A	How many permanent teeth (other than wisdom teeth) have you lost?	Enter number - UN Do not know - DA Prefer not to answer
H2C	Has your dentist told you that you have periodontal disease?	Select from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
H2D	How often do you use dental floss?	Select from - Once daily - Twice daily - Three times daily or more - Two to four times in a week - Once a week or less - Never - Do not remember - Prefer not to answer
H2E	How often do you brush your teeth?	Select from - Once daily - Twice daily - Three times daily or more - Two to four times in a week - Once a week or less - Never - Do not remember - Prefer not to answer

Q. No	Stem	Responses

	Questions for women only:	-
	Has a doctor ever told you that you have polycystic ovarian syndrome / disease?	Select from - YE Yes - NO No - UN Do not know DA Prefer not to answer
	How old were you when the doctor first told you that you had polycystic ovarian syndrome / disease?	Enter number OR UN Do not know OR DA Prefer not to answer
	Are you being treated for polycystic ovarian syndrome / disease?	Select from - YE Yes - NO No - UN Do not know DA Prefer not to answer

Q. No	Stem	Responses
L1	Has a doctor ever told you that you have had any of the following conditions? (You can select more than one answer)	Select from - 04 Obesity - 08 Asthma - 09 Hayfever, allergic rhinitis or eczema - NN None of the above - DA Prefer not to answer
L1A	What was your age when the **** was first diagnosed? *"**** insert each condition from L1 if selected*	Enter number OR UN Do not know OR DA Prefer not to answer
L3	Has a doctor ever told you that you have diabetes?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
L3A	Did you only have diabetes during pregnancy?	Select one from - YE Yes - NO No - NA Not applicable - UN Do not know - DA Prefer not to answer
L3B	What was your age when the diabetes was first diagnosed?	Enter number OR UN Do not know OR DA Prefer not to answer
L3C	Did you start insulin within one year of your diagnosis of diabetes?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
L5	Has a doctor ever told you that you have or had high cholesterol	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
L5A	How old were you when the doctor first told you that you had high cholesterol?	- Age - UN Do not remember - DA Prefer not to answer

L5B	Are you being treated for high cholesterol?	- Diet only - Tablets only - Diet and tablets - No - Prefer not to answer
L6	Has a doctor ever told you that you have or had high blood pressure?	Select one from - YE Yes - NO No - UN Do not know - DA Prefer not to answer
L6A	How old were you when the doctor first told you that you had high blood pressure?	- Age - UN Do not remember - DA Prefer not to answer
L6B	Are you being treated for high blood pressure?	- 01 Diet only - 02 Tablets only - 03 Diet and tablets - NO No - DA Prefer not to answer

Q. No	Stem	Responses
L8	Do you regularly take any of the following? (You can select more than one answer)	Select from: - 01 Aspirin - 03 Paracetamol - NN None of the above - UN Do not know - DA Prefer not to answer
L9	Do you regularly take any PRESCRIPTION medications? (Do not forget medications such as puffers or patches)	Select one from - YE Yes – you will be asked about this later by an interviewer - NO No - UN Do not know - DA Prefer not to answer
L10	Do you regularly take any of the following? (You can select more than one answer)	Select from - 04 Vitamin D -) - 07 Multivitamins +/- minerals - NN None of the above - DA Prefer not to answer
L10A	Do you regularly take any of the following? (You can select more than one answer)	Select from - 01 Fish oil (including cod liver oil) - 05 Iron - NN None of the above - DA Prefer not to answer
L11	How often have you taken a course of antibiotics in the last year?	- 01 Never - 02 Once - 03 Twice - 04 Three times - 05 Four times or more - UN Do not remember - DA Prefer not to answer
L11A	Were the antibiotics taken in the last month?	- 01 Yes - 02 No - UN Do not remember - DA Prefer not to answer
L12	Have you ever had bariatric surgery for weight loss?	Select from - YE Yes - NO No - UN Do not know - DA Prefer not to answer

L12A	How old were you when you had the surgery?	Enter number OR UN Do not know OR DA Prefer not to answer
	Has a doctor ever told you that you have Thalassemia?	Select from - YE Yes - NO No - UN Do not know DA Prefer not to answer
	Has a doctor ever told you that you have Thalassemia trait?	Select from - YE Yes - NO No - UN Do not know DA Prefer not to answer
	Is this?	Select from - α-thalassemia - β-thalassemia - UN Do not know - DA Prefer not to answer

Appendix 2: Summary of prevalence rates for cardiometabolic risk factors.

	Prevalence rates: UAEHFS 2016 - 2018: WHOLE POPULATION		
	Crude	**Age-adjusted**	**Age-standardized**
Obesity	27.2 (25.9 – 28.4)	26.5 (25.2 – 27.7)	30.2 (28.9 - 31.7)
Diabetes	3.9 (3.4 - 4.4)	3.5 (3.0 – 4.0)	4.5 (3.9 - 5.2)
Prediabetes	8.7 (8.0 - 9.5)	8.2 (7.4 – 8.9)	10.1 (9.2 - 11.0)
Abnormal LDL	35.4 (34.1 - 36.7)	34.5 (33.2 – 35.9)	40.4 (38.9 - 41.8)
Abnormal HDL	43.8 (42.5 - 45.2)	43.7 (42.4 – 45.1)	46.7 (45.3 - 48.2)
Abnormal cholesterol	33.9 (32.6 - 35.2)	32.8 (31.4 – 34.1)	39.1 (37.7 - 40.5)
Abnormal Triglycerides	23.1 (21.9 - 24.3)	21.4 (20.2 – 22.6)	27.6 (26.2 - 28.9)
Hypertension	22.9 (21.7 – 24.1)	22.4 (21.2 – 23.6)	25.0 (23.7 - 26.4)
Central obesity	24.3 (23.1 – 25.5)	22.5 (21.3 – 23.8)	29.0 (27.6 - 30.4)

	Prevalence rates: UAEHFS 2016 - 2018: MEN		
	Crude	**Age-adjusted**	**Age-standardized**
Obesity	30.1 (28.5 - 31.8)	29.7 (28 – 31.4)	32.0 (30.3 - 33.8)
Diabetes	4.0 (3.4 - 4.7)	3.8 (3.1 – 4.5)	4.4 (3.7 - 5.3)
Prediabetes	10.6 (9.5 - 11.7)	10.1 (9.1 – 11.2)	11.6 (10.5 - 12.9)
Abnormal LDL	42.5 (40.8 - 44.2)	42.1 (40.3 – 43.9)	46.0 (44.2 - 47.8)
Abnormal HDL	45.5 (43.7 - 47.2)	45.4 (43.6 – 47.1)	47.9 (46.1 - 49.8)
Abnormal cholesterol	38.0 (36.4 - 39.7)	37.2 (35.4 – 38.9)	41.8 (40.1 - 43.6)
Abnormal Triglycerides	28.2 (26.6 - 29.8)	26.7 (25.1 – 28.3)	31.9 (30.2 - 33.6)
Hypertension	31.0 (29.4 - 32.7)	30.9 (29.2 – 32.6)	32.1 (30.4 - 33.9)
Central obesity	30.9 (29.3 - 32.6)	29.6 (27.9 – 31.3)	34.8 (33 - 36.6)

	Prevalence rates: UAEHFS 2016 - 2018: WOMEN		
	Crude	**Age-adjusted**	**Age-standardized**
Obesity	22.6 (20.8 - 24.6)	21.6 (19.7 – 23.5)	27.4 (25.1 - 29.8)
Diabetes	3.6 (2.9 - 4.5)	3.1 (2.3 – 3.9)	4.7 (3.7 - 6.1)
Prediabetes	5.6 (4.7 - 6.8)	5.2 (4.1 – 6.2)	6.9 (5.7 - 8.4)
Abnormal LDL	23.9 (22.0 - 25.8)	22.9 (20.9 – 24.8)	28.8 (26.5 - 31.3)
Abnormal HDL	41.2 (39.0 - 43.4)	41.1 (38.9 – 43.3)	44.1 (45.6 - 46.7)
Abnormal cholesterol	27.0 (25.1 - 29.1)	26.0 (24.0 – 28)	33.0 (30.6 - 35.5)
Abnormal Triglycerides	14.8 (13.3 - 16.4)	13.5 (11.9 – 15.1)	18.9 (16.9 - 21.2)
Hypertension	9.9 (8.7 - 11.4)	9.2 (7.8 – 10.5)	12.1 (10.5 - 14.0)
Central obesity	13.9 (12.4 - 15.5)	12.5 (10.9 – 14.0)	17.9 (15.9 - 20.1)