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# Cardiovascular Disease Risk, Prevalence, and Care Cascades of Metabolic Disorders Among Iranians With Elevated Blood Pressure

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## Abstract

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality among individuals with elevated blood pressure. National evidence on CVD burden and predicted risk among hypertensive and prehypertensive adults in Iran remains limited. This study assessed the prevalence of established CVD, 10-year predicted risk, and associated sociodemographic and metabolic characteristics in these groups. Data from 18,418 hypertensive and prehypertensive adults in the nationally representative 2021 WHO STEPS survey were analyzed. Hypertension and prehypertension were defined using JNC criteria. CVD was self-reported, and 10-year ASCVD risk was estimated using the Framingham Risk Score, with all analyses accounting for survey design and weights. CVD prevalence was 15.96% (95% CI: 15.10–16.83) in hypertensives and 4.56% (4.10–5.03) in prehypertensives, with higher rates in males, older adults, unemployed individuals, and those with lower education. Diabetes and dyslipidemia were significantly more common among individuals with CVD, while treatment control remained suboptimal. Treated and controlled hypertension and diabetes were more frequent among CVD-positive participants, yet notable proportions remained untreated. High 10-year predicted ASCVD risk was observed in 31.7% of hypertensives and 7.9% of prehypertensives, with strong gradients by age, sex, and socioeconomic status. These findings demonstrate a substantial burden of established and predicted CVD risk among adults with elevated blood pressure in Iran and highlight the need for integrated, risk-based prevention and management strategies.


## Introduction

Cardiovascular disease (CVD) encompasses a broad range of disorders affecting the heart and blood vessels, including coronary artery disease, heart failure, stroke, and peripheral artery disease [1].

CVDs particularly ischemic heart disease and stroke are the leading cause of death and a major contributor to disability worldwide. Between 1990 and 2019, the global number of CVD cases nearly doubled, rising from 271 million to 523 million, while related deaths increased from 12.1 million to 18.6 million[2] , which is expected to exceed 23.6 million by 2030 [3].

In the North Africa and Middle East (NAME) region, the burden of CVD has grown steadily. From 1990 to 2021, prevalence increased from 17.3 million to 17.7 million, and incidence rose from 2.29 million to 5.66 million. Despite this growth, age-standardized rates have remained relatively stable, suggesting demographic shifts rather than rising individual risk are driving the increase[4] .

According to JNC guidelines, hypertension is defined as systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg, while prehypertension falls within SBP 120–139 mmHg or DBP 80–89 mmHg[6 ,5] . Hypertension is one of the most important modifiable risk factors for CVD[7]. According to the World Health Organization, the age-standardized prevalence of hypertension was 33% in 2019, affecting more than 1.3 billion adults aged 30-79 double the number reported in 1990 [2, 8, 9]. In Iran, the burden is also substantial, with research indicating that about 32.0% of adults are affected by the condition [10]. Prehypertension is an early stage that often progresses to hypertension and is independently linked to a significant increase in cardiovascular disease (CVD) morbidity and mortality. As individuals age, prehypertension frequently develops into full hypertension, and its prevalence among younger populations is rising, particularly in low- and middle-income countries [11, 12]. Studies show that individuals with uncontrolled or untreated hypertension face a significantly higher risk of cardiovascular events and mortality compared to those with normal blood pressure, emphasizing the need for early detection and effective management [13, 14].

To date, no nationally representative study has comprehensively examined the associations between sociodemographic factors, health behaviors, and metabolic risk profiles with either existing CVD or predicted CVD risk—based on the Framingham score—among hypertensive individuals without established CVD in Iran. This lack of evidence hinders the identification of vulnerable subgroups and the design of tailored interventions. The 2021 WHO STEPS survey in Iran, conducted using the World Health Organization’s standardized STEPwise approach to NCD risk factor surveillance, offers a unique opportunity to address this gap [15]. This study aimed to provide comprehensive data on cardiovascular disease (CVD)-associated factors among individuals with prehypertension and hypertension in Iran.

# Method

### Study design and participants

This secondary analysis uses data from the 2021 WHO STEPS survey in Iran, a nationally representative cross-sectional study monitoring non-communicable disease risk factors [16]. The survey included three steps: questionnaires (n=27,874), physical measurements (n=27,745), and laboratory assessments (n=18,119, aged ≥25 years). Conducted across all 31 provinces, the survey sampled adults aged 18 and older from urban and rural areas using systematic cluster random sampling. Exclusions applied to pregnant individuals, those unable to complete assessments, or those who declined consent. For this analysis, participants with data on hypertension, prehypertension, and cardiovascular disease were included. Hypertension was defined by systolic BP ≥140 mmHg, diastolic BP ≥90 mmHg, or antihypertensive medication use. Prehypertension was systolic BP 120–139 mmHg or diastolic BP 80–89 mmHg without medication. A total of 18,418 individuals qualified: 8,806 hypertensive and 9,612 prehypertensive.

### Data Collection

Weight was measured with a calibrated digital scale while participants wore light clothing and no shoes. Waist circumference was taken midway between the lowest rib and iliac crest at the umbilicus level. Blood pressure was measured three times on the right arm after a 15-minute rest, using standard sphygmomanometers, with the average of the second and third readings used for analysis. All lab tests were performed at a central reference laboratory.

### Variable Definition

Hypertension, defined according to the JNC 8 guideline as a systolic blood pressure (SBP) ≥140 mmHg, diastolic blood pressure (DBP) ≥90 mmHg, or current use of antihypertensive medication [6]. Prehypertension was defined based on the JNC 7 classification (as JNC 8 does not specify a prehypertension category) as SBP between 120–139 mmHg or DBP between 80–89 mmHg, without the use of antihypertensive medications [5]. Treatment coverage referred to the proportion of individuals with diagnosed hypertension who were receiving standard antihypertensive medications, regardless of blood pressure control. Effective treatment was defined as achieving a mean SBP <140 mmHg and DBP <90 mmHg while on therapy.

The Framingham Risk Score (FRS) estimates 10-year cardiovascular risk based on age, sex, cholesterol levels, blood pressure, hypertension treatment, smoking, and diabetes, categorizing risk as low (<10%), moderate (10–19%), or high (≥20%) [17, 18].

Cardiovascular disease (CVD) history was defined by self-reported heart attack, angina, or stroke.

Educational status was evaluated by categorizing years of schooling into three groups: 0–6 years, 7–11 years, and 12 years or more. Wealth status was assessed by a household assets questionnaire analyzed via principal component analysis, categorized into five socioeconomic quintiles.

Physical activity was measured by the Global Physical Activity Questionnaire, with ≥600 MET minutes/week deemed sufficient [19].

Alcohol use was categorized as current (ever and past-year use), past (ever but not recent use), or never. Tobacco use was classified as current (any use in the past year or ever), past (ever but not recent use), passive (never used but exposed to secondhand smoke in the past 30 days), or never.

Fruit and vegetable intake was assessed by average daily servings, with ≥5 servings per day considered appropriate consumption [20].

BMI categories were underweight/normal (<25), overweight (25–<30), and obese (≥30). Abdominal obesity was defined by waist circumference ≥102 cm (men) or ≥88 cm (women) [21].

Diabetes was defined by fasting plasma glucose ≥126 mg/dl, HbA1c ≥6.5%, or antidiabetic medication use; prediabetes was FPG 100–125 mg/dl or HbA1c 5.7–6.4% and no antidiabetic medication use [22].

Lipid abnormalities were defined based on NCEP ATP III criteria: hypertriglyceridemia as TG ≥ 150 mg/dL (1.7 mmol/L), hypercholesterolemia as TC ≥ 200 mg/dL (5.2 mmol/L), high LDL-C as ≥ 130 mg/dL (3.4 mmol/L), and low HDL-C as < 40 mg/dL (1.03 mmol/L) in men or < 50 mg/dL (1.29 mmol/L) in women. Dyslipidemia was defined as having any of these abnormalities or using lipid-lowering medications [23, 24].

The dyslipidemia cascade of care was defined based on medication use and lipid control. Control defined as triglycerides <150 mg/dL, total cholesterol <200 mg/dL, LDL <130 mg/dL, and HDL ≥40 mg/dL in men or ≥50 mg/dL in women. Participants were categorized as untreated, treated but uncontrolled, or treated and controlled. Similarly, the diabetes cascade was defined using medication use and HbA1c levels, with treated and controlled defined as HbA1c < 7% among those receiving antidiabetic medication [25].

**Statistical Analysis:**

The weighting procedure was conducted in four stages: (a) adjustment for general non-response (non-participation in the study), (b) step-specific non-response weighting for questionnaires, anthropometric, and laboratory data, (c) post-stratification by age, sex, and area of residence, and (d) calculation of final weights for each survey step based on the previous three stages.

Descriptive analyses included weighted percentages with 95% confidence intervals (CI) for categorical variables and weighted means with 95% CI for continuous variables.

The 10-year cardiovascular risk was calculated using the Framingham Risk Score through the CVrisk package[26]. Participants aged 30 to 74 years without a history of cardiovascular disease were categorized into three risk groups: low (<10%), moderate (10–19%), and high (≥20%). For each analysis, participants with available data for the variable of interest were included in the corresponding estimates. All analyses were performed using R version 4.4.0, and the complex survey design was accounted for using the survey package [27].

# Results

**Prevalence of CVD in Hypertensive and Prehypertensive Adults**

Among hypertensive individuals (n=8,806), 15.96% (95% CI: 15.10–16.83) had CVD, compared to 4.56% (4.10–5.03) in prehypertensives (n=9,612), indicating a markedly higher CVD prevalence in hypertensives (Table 1).

In both groups, males had higher CVD prevalence than females: hypertensive males 18.72% vs. females 13.86%; prehypertensive males 5.82% vs. females 3.22%. CVD prevalence increased with age: in hypertensives, from 3.44% (25–44 years) to 25.72% (≥65); in prehypertensives, from 1.35% to 16.26% across the same age groups.

Employment status showed strong gradients: hypertensive retirees had 27.16% (24.57–29.76) CVD, unemployed 22.96% (18.64–27.28), vs. employed (11.33%, 9.87–12.80) and unpaid workers (13.98%, 12.84–15.11). Similar patterns held for prehypertensives.

Lower educational attainment was associated with higher CVD prevalence in both groups: hypertensive participants with ≤6 years had 18.16% (16.98–19.34) vs. 12.64% (11.07–14.20) for ≥12 years.

Former smokers had the highest CVD prevalence: hypertensives 25.87%, prehypertensives 9.40%, significantly higher than current and never smokers in both groups.

In the hypertensive group, CVD prevalence was higher in treated individuals: 22.96% (21.17–24.74) in treated-uncontrolled and 24.60% (22.44–26.75) in treated-controlled, versus 7.25% (6.35–8.16) in untreated.

In the hypertensive group, worsening glycemic status was linked to a higher CVD prevalence: diabetics had 24.92% (22.07–27.78) vs. 7.72% (5.83–9.60) in normoglycemic individuals, and prediabetics had 13.92% (12.26–15.57).

**Framingham Risk Score Categories Prevalence in Hypertensive and Prehypertensive Adults**

Among participants aged 30–74 years with no established cardiovascular disease (CVD), the overall distribution of cardiovascular risk levels differed between hypertensive and prehypertensive groups. In hypertensive group, 37.48% (95% CI: 35.47–39.48) were low risk, 30.81% (29.00–32.62) moderate, and 31.71% (29.88–33.54) high. In prehypertensives, 76.29% (74.63–77.96) were low risk, 15.81% (14.49–17.14) moderate, and 7.89% (6.68–9.10) high (Table 2).

Among hypertensives, females had higher low-risk (45.09%) and lower high-risk (20.83%) profiles than males (low-risk: 26.13%, high-risk: 47.94%). A similar pattern was seen in prehypertensives, with females showing 90.83% low-risk and 0.90% high-risk, compared to males with 60.92% low-risk and 15.28% high-risk.

Among hypertensive participants, the retired group had the highest prevalence of high risk at 68.16% (63.01–73.30), significantly higher than unemployed (50.78%, 41.62–59.95), employed (31.36%, 27.98–34.74), and unpaid individuals (21.15%, 19.13–23.18). For low risk, the unpaid group showed the highest prevalence at 44.56% (41.91–47.20), with other categories ranging from 6.11% to 40.08%.

Years of schooling was inversely associated with CVD risk. Among hypertensives, 48.17% of those with ≥12 years of education were low risk vs. 28.95% among those with ≤6 years. Similar trends were observed among prehypertensives.

In wealth quintiles, hypertensives in the lower-middle had higher high-risk prevalence (39.18%, 34.58–43.79) vs. the highest quintile (27.48%, 22.71–32.25).

Significant differences in Framingham risk scores were observed by alcohol consumption. Among hypertensive individuals, former (35.93%) and current drinkers (43.48%) had higher high-risk prevalence compared to never drinkers (31.30%). In prehypertensive individuals, former drinkers had lower low-risk and higher moderate-risk prevalence than never drinkers.

**Metabolic Indicators and Care Cascade in Hypertensive and Prehypertensive Adults by CVD and Risk Stratification**

Compared to individuals without CVD, those with CVD had greater waist circumference, lower diastolic blood pressure, and reduced levels of HDL-C, LDL-C, total cholesterol, and triglycerides in both hypertensive and prehypertensive groups. They also exhibited higher fasting blood sugar and HbA1c levels across both groups (Tables 3).

Among hypertensive patients, those with CVD had a lower percentage of no diabetes (49.07% vs. 69.95%) and a higher percentage of untreated diabetes (19.5% vs. 14.54%) and treated but uncontrolled diabetes (21.81% vs. 11.04%) compared to CVD-negative patients (Figure 1). Treated and controlled diabetes was also more common in the CVD-positive group (9.62% vs. 4.48%). When comparing individuals with CVD to those in the high Framingham risk group, untreated diabetes was more common in the high-risk group (26.68%, 23.64–29.72) than in those with established CVD (19.5%, 15.67–23.32).

Overall, dyslipidemia was prevalent among hypertensive patients, with only 11.26% of CVD-positive and 13.89% of CVD-negative hypertensives had normal lipid profiles. Untreated dyslipidemia affected 65.33% of high-risk, 67.9% of CVD-negative, and 46.67% of CVD-positive individuals. Treated but uncontrolled dyslipidemia was higher in CVD-positive (36.54%) than high-risk (20.82%), while treated and controlled dyslipidemia was also more common in CVD-positive (5.53%) than high-risk (2.75%).

Treated and controlled hypertension was more prevalent in CVD-positive (34.32%) than high-risk (14.73%) individuals; untreated hypertension was more common in the high-risk group (39.32%) vs. CVD-positive (21.26%).

In prehypertensive participants, both diabetes and dyslipidemia cascades indicated a deterioration in metabolic health with increasing FRS category. The proportion of participants without diabetes decreased from 93.76% in the low-risk group to 58.53% in the high-risk group. Meanwhile, untreated diabetes was substantially more prevalent in the high-risk group (26.61%) compared to low-risk group (3.72%). Similarly, untreated dyslipidemia was most common in the high-risk group (78.59%)

compared to 73.98% in the low-risk group, while the proportion of individuals with treated and controlled dyslipidemia was minimal across all groups (Supplementary Table 1).

## Discussion

In the current cross-sectional study involving 18,418 individuals from all provinces across Iran, we investigated cardiovascular diseases among patients with hypertension and prehypertension based on socioeconomic status, lifestyle factors, comorbidities, and laboratory test findings. This study reveals a significant burden of cardiovascular disease (CVD) among Iranian adults with hypertension and prehypertension, with a higher prevalence of established CVD in those with hypertension (about 16%) compared to those with prehypertension (around 5%). Based on the Global Burden of Disease (GBD) 2021 data, the global prevalence of cardiovascular disease (CVD) among adults is estimated to range between 6% and 9% [28]. However, due to limited reporting on CVD prevalence specifically among individuals with hypertension, our study highlights a notable difference: the prevalence of CVD in individuals with hypertension was 16%, which is significantly higher than that observed in the general adult population. Among adults aged 30 to 74 years without established cardiovascular disease (CVD), we observed a marked difference in 10-year predicted CVD risk between individuals with hypertension and those with prehypertension. Approximately one-third of individuals with hypertension were classified as high risk for developing CVD, whereas over 70% of those with prehypertension remained at low risk. These findings emphasize the importance of early detection, risk stratification, and targeted interventions to prevent progression and reduce cardiovascular complications.

Sex disparities were evident across both blood pressure categories. Males had higher CVD prevalence than females, a trend seen in both hypertensive and prehypertensive groups. This finding aligns with global studies that report higher CVD rates in males [29, 30].

The prevalence of CVD varied notably across socioeconomic groups, particularly by employment and education status. Retired and unemployed individuals exhibited substantially higher CVD prevalence, possibly due to limited access to care, lower income, or higher burden of comorbidities [31]. Similarly, those with lower education had significantly higher CVD prevalence, a finding consistent with previous research that links lower educational attainment to reduced health literacy, fewer preventive behaviors, and greater cardiovascular risk, regardless of other key socioeconomic factors [32-34]. The prevalence of high Framingham 10-year CVD risk was lower among individuals with higher education and those who were employed, suggesting a potential protective effect. These differences may reflect healthier lifestyles, better access to healthcare, and improved adherence to treatment among more educated and employed individuals. In a previous study, years of schooling were found to be inversely associated with 10-year coronary heart disease (CHD) risk scores [35].

According to a meta-analysis, any physical exercise is related to lower cardiovascular risk, and the benefit grows as the amount of weekly physical activity increases [36]. In our study, the prevalence of cardiovascular events was higher among hypertensive individuals with insufficient physical activity compared to those with sufficient activity levels, which emphasizes the protective role of regular exercise.

While antihypertensive medication plays a key role in lowering blood pressure and reducing CVD risk, the independent effects of lifestyle modification remain less clear. Nonetheless, maintaining healthy behaviors—such as a balanced diet, physical activity, avoiding tobacco and alcohol, and managing weight—can reduce CVD risk by up to 30% and lower systolic BP by about 3.5 mmHg, regardless of genetic predisposition. These findings highlight the importance of addressing both lifestyle and socioeconomic determinants in cardiovascular prevention strategies [35].

Among hypertensive individuals, CVD prevalence increases progressively from normoglycemia to diabetes, indicating metabolic synergy, where coexisting conditions compound vascular damage [37].

CVD prevalence was significantly higher among hypertensive individuals receiving treatment (both controlled and uncontrolled) compared to untreated patients. This may seem paradoxical but likely reflects treatment being initiated in response to existing disease or higher risk. It emphasizes that while treatment is necessary, earlier intervention before disease manifestation is more effective in reducing long-term burden.

The study reveals significant gaps in disease management, particularly among high cardiovascular risk individuals. Individuals with established cardiovascular disease (CVD) generally show better engagement across the care continuum, with higher proportions of treated and controlled cases for all three conditions compared to their CVD-negative and high Framingham risk counterparts. However, a notable proportion of CVD-positive individuals remained with uncontrolled or untreated conditions, suggesting that optimal control is not consistently achieved. High-risk individuals without established CVD were more likely to have untreated diabetes and dyslipidemia, indicating missed opportunities for early intervention.

The study also found that only 19.8% of individuals with CVD had untreated hypertension, compared to 48.9% of those without CVD, whereas 45.9% of treated CVD patients remained uncontrolled (versus 30.4% in the non-CVD group). This trend may be due to more aggressive hypertension management, higher load of adverse risk factors, and inadequate treatment intensification in the presence of numerous comorbidities or poor adherence to complicated prescription regimens. The study highlights the importance of improved blood pressure management and medication adherence in individuals with cardiovascular disease (CVD) to improve hypertension control. Studies show that treated uncontrolled hypertensives have a higher risk of all-cause and cardiovascular mortality compared to treated controlled hypertensives [38, 39]. The study emphasizes the advantages of secondary prevention in hypertensive individuals and primary prevention in the general population to mitigate the risk of mortality in later life.

Similar to hypertension, we observed a significant proportion of patients with dyslipidemia who were treated but failed to reach target lipid levels—36.26% in the CVD group compared to just 15.83% in the non-CVD group. This pattern aligns with findings from a study on Chinese patients with acute coronary syndrome [40], where 63.8% had uncontrolled lipid levels at enrollment. In our population, many individuals in the CVD group may have been on multiple medications, increasing the risk of side effects, drug interactions, and statin-related complications, especially in older adults.

This study draws on a nationally representative dataset, supported by robust multistage sampling and appropriate weighting, which enhances the generalizability of the findings to the Iranian adult population. However, several limitations should be noted. The cross-sectional design precludes causal inference, and in some cases, observed associations may be influenced by reverse causality. CVD history was determined based on self-report, which may be prone to recall bias or misclassification. Certain behavioral variables (e.g., tobacco and alcohol use) are also subject to underreporting due to social desirability bias.

These findings underscore the urgent need for national policies that promote early detection, risk stratification, and integrated management of hypertension, diabetes, and dyslipidemia—especially in underserved populations.

## Conclusion

This large-scale cross-sectional study of nearly 10,000 Iranian adults reveals a substantial burden of cardiovascular disease (CVD) among individuals with hypertension and prehypertension. Key determinants of increased CVD prevalence included older age, female sex, lower socioeconomic and educational status, and unhealthy behaviors such as smoking and alcohol use. Furthermore, substantial gaps persist across the care cascade. Although patients with established CVD were more likely to receive treatment for hypertension, diabetes, and dyslipidemia, many remained uncontrolled, suggesting insufficient intensification or adherence support. Equally concerning, high-risk individuals without diagnosed CVD often remained untreated, representing missed primary prevention opportunities.

## Declarations

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**Authors' Contributions**

Conceptualization: M.M., S.S., K.K., A.G.; Methodology: M.M., S.S., A.G.; Formal Analysis: M.M.; Investigation: M.M., S.S., K.K., A.G.; Resources: M.M., S.S.; Data Curation: M.M., A.G.; Validation: M.M., A.G., S.S., K.K, F.F..; Writing – Original Draft: M.M., S.S.; Writing – Review & Editing: M.M., S.S., A.G., K.K.,F.F.; Supervision: A.G.; Project Administration: M.M., S.S.

M.M. and S.S. share equal contribution as first authors.

**Data availability statement**

The datasets generated and analyzed during the current study are not publicly available due to institutional restrictions but are available from the corresponding author upon reasonable request.

**Ethics declarations**

This study was approved by the Research Ethics Committee of the Endocrine & Metabolism Research Institute at Tehran University of Medical Sciences (IR.TUMS.EMRI.REC.1403.098), in accordance with the Declaration of Helsinki. Written informed consent was obtained prior to enrollment during the Iran STEPS 2021 survey. To ensure confidentiality, all data were anonymized before analysis. Access to the dataset was restricted to the principal investigator and the database manager.

**Competing Interests**

The authors declare no competing interests.

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# Tables

**Table 1.** Prevalence of Cardiovascular Disease among Hypertensive and Prehypertensive Individuals across Demographic, Behavioral, and Health-related Characteristics.

| | | | Hypertensive Group | | | Prehypertensive Group | |
|---|---|---|---|---|---|---|---|
| **Variable** | **Category** | **N** | **CVD-Negative (n = 7,432)** | **CVD-Positive (n = 1,374)** | **N** | **CVD-Negative (n = 9,179)** | **CVD-Positive (n = 433)** |
| Total | | 8806 | 84.04 (83.17-84.9) | 15.96 (15.1-16.83) | 9612 | 95.44 (94.97-95.9) | 4.56 (4.1-5.03) |
| Sex | Male | 8806 | 81.28 (79.87-82.69) | 18.72 (17.31-20.13) | 9612 | 94.18 (93.45-94.9) | 5.82 (5.1-6.55) |
| | Female | | 86.14 (85.07-87.22) | 13.86 (12.78-14.93) | | 96.78 (96.21-97.34) | 3.22 (2.66-3.79) |
| Age Group | 25-44 | 8806 | 96.56 (95.57-97.56) | 3.44 (2.44-4.43) | 9612 | 98.65 (98.31-99) | 1.35 (1-1.69) |
| | 45-64 | | 85.31 (84.13-86.49) | 14.69 (13.51-15.87) | | 93.4 (92.48-94.32) | 6.6 (5.68-7.52) |
| | ≥65 | | 74.28 (72.42-76.14) | 25.72 (23.86-27.58) | | 83.74 (80.96-86.52) | 16.26 (13.48-19.04) |
| Residential Area | Rural | 8806 | 85.65 (84.01-87.29) | 14.35 (12.71-15.99) | 9612 | 96.06 (95.19-96.93) | 3.94 (3.07-4.81) |
| | Urban | | 83.51 (82.49-84.52) | 16.49 (15.48-17.51) | | 95.24 (94.69-95.79) | 4.76 (4.21-5.31) |
| Marital Status | Unmarried/Previously Married | 8806 | 82.62 (80.6-84.65) | 17.38 (15.35-19.4) | 9612 | 96.95 (96.12-97.78) | 3.05 (2.22-3.88) |
| | Married | | 84.37 (83.42-85.33) | 15.63 (14.67-16.58) | | 95.02 (94.47-95.56) | 4.98 (4.44-5.53) |
| Employment Status | Unemployed | 8743 | 77.04 (72.72-81.36) | 22.96 (18.64-27.28) | 9546 | 91.8 (89.12-94.47) | 8.2 (5.53-10.88) |
| | Unpaid | | 86.02 (84.89-87.16) | 13.98 (12.84-15.11) | | 96.93 (96.35-97.52) | 3.07 (2.48-3.65) |
| | Employed | | 88.67 (87.2-90.13) | 11.33 (9.87-12.8) | | 96.75 (96.15-97.35) | 3.25 (2.65-3.85) |
| | Retired | | 72.84 (70.24-75.43) | 27.16 (24.57-29.76) | | 82.46 (79.42-85.5) | 17.54 (14.5-20.58) |
| Years of Schooling | Illiterate/1–6 years | 8743 | 81.84 (80.66-83.02) | 18.16 (16.98-19.34) | 9546 | 92.4 (91.38-93.43) | 7.6 (6.57-8.62) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 7–11 years | | 86.53 (84.38-88.69) | 13.47 (11.31-15.62) | | 97.2 (96.41-97.98) | 2.8 (2.02-3.59) |
| | ≥12 years | | 87.36 (85.8-88.93) | 12.64 (11.07-14.2) | | 96.85 (96.26-97.44) | 3.15 (2.56-3.74) |
| Wealth Index | Lowest Quintile | 8398 | 82.47 (80.56-84.37) | 17.53 (15.63-19.44) | 9087 | 96 (95-97) | 4 (3-5) |
| | Lower-Middle Quintile | | 82.05 (80.04-84.06) | 17.95 (15.94-19.96) | | 94.71 (93.53-95.88) | 5.29 (4.12-6.47) |
| | Middle Quintile | | 84.25 (82.24-86.26) | 15.75 (13.74-17.76) | | 94.39 (93.18-95.59) | 5.61 (4.41-6.82) |
| | Upper-Middle Quintile | | 84.65 (82.66-86.64) | 15.35 (13.36-17.34) | | 95.33 (94.25-96.4) | 4.67 (3.6-5.75) |
| | Highest Quintile | | 85.99 (83.94-88.03) | 14.01 (11.97-16.06) | | 96.15 (95.21-97.09) | 3.85 (2.91-4.79) |
| Insurance Coverage | None | 8716 | 91.52 (89.03-94.01) | 8.48 (5.99-10.97) | 9505 | 97.68 (96.62-98.75) | 2.32 (1.25-3.38) |
| | Basic | | 86.64 (85.57-87.7) | 13.36 (12.3-14.43) | | 96.34 (95.82-96.86) | 3.66 (3.14-4.18) |
| | Basic-complementary | | 78.88 (77.28-80.48) | 21.12 (19.52-22.72) | | 92.17 (90.95-93.38) | 7.83 (6.62-9.05) |
| Physical Activity | Insufficient | 8757 | 81.46 (80.17-82.75) | 18.54 (17.25-19.83) | 9544 | 95.17 (94.44-95.9) | 4.83 (4.1-5.56) |
| | Sufficient | | 86.75 (85.61-87.9) | 13.25 (12.1-14.39) | | 95.68 (95.07-96.28) | 4.32 (3.72-4.93) |
| Alcohol Consumption | Never Drank | 8735 | 84.44 (83.55-85.32) | 15.56 (14.68-16.45) | 9524 | 95.48 (95-95.97) | 4.52 (4.03-5) |
| | Former Drinker | | 71.74 (65.2-78.28) | 28.26 (21.72-34.8) | | 91.77 (88.42-95.13) | 8.23 (4.87-11.58) |
| | Current Drinker | | 81.36 (75.45-87.28) | 18.64 (12.72-24.55) | | 97.36 (95.62-99.11) | 2.64 (0.89-4.38) |
| Tobacco Use | Never Smoked | 8800 | 84.09 (82.97-85.21) | 15.91 (14.79-17.03) | 9606 | 95.73 (95.13-96.34) | 4.27 (3.66-4.87) |
| | Passive Exposure | | 86.65 (84.99-88.31) | 13.35 (11.69-15.01) | | 95.89 (94.98-96.81) | 4.11 (3.19-5.02) |
| | Former Smoker | | 74.13 (69.88-78.37) | 25.87 (21.63-30.12) | | 90.6 (87.67-93.52) | 9.4 (6.48-12.33) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Current Smoker | | 83.89 (81.36-86.42) | 16.11 (13.58-18.64) | | 95.26 (94.08-96.44) | 4.74 (3.56-5.92) |
| Daily Fruit & Vegetable Intake | Insufficient | 8797 | 83.63 (82.69-84.57) | 16.37 (15.43-17.31) | 9605 | 95.46 (94.95-95.96) | 4.54 (4.04-5.05) |
| | Sufficient | | 86.67 (84.46-88.88) | 13.33 (11.12-15.54) | | 95.29 (94.04-96.55) | 4.71 (3.45-5.96) |
| BMI | Normal/Underweight | 8797 | 85.28 (83.55-87.02) | 14.72 (12.98-16.45) | 9601 | 95.85 (95.11-96.58) | 4.15 (3.42-4.89) |
| | Overweight | | 83.51 (82.12-84.9) | 16.49 (15.1-17.88) | | 95.22 (94.46-95.97) | 4.78 (4.03-5.54) |
| | Obese | | 83.85 (82.42-85.29) | 16.15 (14.71-17.58) | | 95.17 (94.19-96.16) | 4.83 (3.84-5.81) |
| WC | Normal | 8806 | 84.96 (83.53-86.39) | 15.04 (13.61-16.47) | 9612 | 95.8 (95.21-96.4) | 4.2 (3.6-4.79) |
| | High | | 83.53 (82.45-84.62) | 16.47 (15.38-17.55) | | 94.99 (94.25-95.72) | 5.01 (4.28-5.75) |
| Hypertension status | Untreated | 8806 | 92.75 (91.84-93.65) | 7.25 (6.35-8.16) | | | |
| | Treated-Uncontrolled | | 77.04 (75.26-78.83) | 22.96 (21.17-24.74) | | | |
| | Treated-Controlled | | 75.4 (73.25-77.56) | 24.6 (22.44-26.75) | | | |
| Diabetes status | Normal | 6433 | 92.28 (90.4-94.17) | 7.72 (5.83-9.6) | 6024 | 96.67 (95.77-97.58) | 3.33 (2.42-4.23) |
| | Prediabetic | | 86.08 (84.43-87.74) | 13.92 (12.26-15.57) | | 95.95 (95.06-96.84) | 4.05 (3.16-4.94) |
| | Diabetic | | 75.08 (72.22-77.93) | 24.92 (22.07-27.78) | | 85.91 (82.16-89.65) | 14.09 (10.35-17.84) |
| Dyslipidemia | No | 6478 | 86.23 (82.92-89.53) | 13.77 (10.47-17.08) | 6051 | 95.97 (94.69-97.25) | 4.03 (2.75-5.31) |
| | Yes | | 83.13 (81.71-84.55) | 16.87 (15.45-18.29) | | 94.6 (93.7-95.5) | 5.4 (4.5-6.3) |

CVD = Cardiovascular Disease; BMI = Body Mass Index; WC = waist circumference; CI = Confidence Interval.

N indicates the number of participants with non-missing data for each variable in the hypertensive and prehypertensive groups.

Values are weighted percentages (95% CI) of CVD-positive and CVD-negative participants among hypertensive and prehypertensive individuals.

**Table 2.** Framingham 10-Year Cardiovascular Risk Categories by Demographic, Behavioral, and Health Characteristics in Hypertensive and Prehypertensive Individuals

| | | | Hypertensive Group | | | | Prehypertensive Group | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **Category** | **N** | **Low Risk (n= 1,822)** | **Moderate Risk (n = 1,518)** | **High Risk (n = 1,584)** | **N** | **Low Risk (n= 3,878)** | **Moderate Risk (n = 834)** | **High Risk (n = 375)** |
| Total | | 4924 | 37.48 (35.47-39.48) | 30.81 (29-32.62) | 31.71 (29.88-33.54) | 5087 | 76.29 (74.63-77.96) | 15.81 (14.49-17.14) | 7.89 (6.68-9.1) |
| Sex | Male | 4924 | 26.13 (22.9-29.36) | 25.93 (23.14-28.72) | 47.94 (44.67-51.21) | 5087 | 60.92 (58.15-63.7) | 23.79 (21.56-26.02) | 15.28 (12.97-17.6) |
| | Female | | 45.09 (42.55-47.62) | 34.09 (31.73-36.44) | 20.83 (18.79-22.86) | | 90.83 (89.34-92.32) | 8.27 (6.83-9.71) | 0.9 (0.48-1.33) |
| Age Group | 25-44 | 4924 | 85.94 (82.94-88.95) | 13.28 (10.32-16.24) | 0.78 (0.2-1.36) | 5087 | 96.82 (95.96-97.68) | 3.09 (2.24-3.94) | 0.09 (0-0.17) |
| | 45-64 | | 30.23 (27.96-32.5) | 38.65 (36.21-41.1) | 31.11 (28.83-33.4) | | 62.62 (59.85-65.38) | 26.64 (24.22-29.06) | 10.74 (8.71-12.77) |
| | ≥65 | | 5.04 (2.87-7.22) | 28.09 (24.34-31.84) | 66.87 (62.84-70.9) | | 23.09 (15.63-30.56) | 35.12 (27.89-42.35) | 41.79 (33.62-49.96) |
| Residential Area | Rural | 4924 | 38.54 (35.67-41.41) | 29.68 (26.95-32.42) | 31.78 (29.05-34.51) | 5087 | 76.5 (74-78.99) | 16.02 (13.84-18.19) | 7.49 (5.97-9) |
| | Urban | | 37.14 (34.65-39.62) | 31.17 (28.95-33.39) | 31.69 (29.44-33.94) | | 76.23 (74.18-78.28) | 15.75 (14.15-17.36) | 8.02 (6.5-9.53) |
| Marital Status | Unmarried/Previously Married | 4924 | 37.67 (32.44-42.9) | 33.02 (28.23-37.82) | 29.31 (24-34.61) | 5087 | 88.21 (84.83-91.6) | 9.96 (6.72-13.2) | 1.82 (0.71-2.94) |
| | Married | | 37.44 (35.27-39.61) | 30.42 (28.46-32.37) | 32.14 (30.2-34.08) | | 74.52 (72.68-76.35) | 16.69 (15.24-18.13) | 8.79 (7.43-10.16) |
| Employment Status | Unemployed | 4892 | 29.79 (20.62-38.97) | 19.42 (12.62-26.22) | 50.78 (41.62-59.95) | 5056 | 66.17 (57.88-74.45) | 15.98 (10.15-21.82) | 17.85 (11.52-24.19) |
| | Unpaid | | 44.56 (41.91-47.2) | 34.29 (31.8-36.78) | 21.15 (19.13-23.18) | | 89.95 (88.25-91.65) | 8.8 (7.18-10.42) | 1.25 (0.69-1.81) |
| | Employed | | 40.08 (36.03-44.13) | 28.56 (25.19-31.93) | 31.36 (27.98-34.74) | | 74.68 (72.28-77.09) | 17.84 (15.87-19.82) | 7.47 (5.87-9.07) |
| | Retired | | 6.11 (3.8-8.42) | 25.73 (20.88-30.58) | 68.16 (63.01-73.3) | | 20.29 (14.78-25.8) | 40.08 (32.68-47.48) | 39.63 (31.54-47.72) |
| Years of Schooling | Illiterate/1–6 years | 4892 | 28.95 (26.86-31.04) | 34.49 (32.24-36.75) | 36.56 (34.32-38.79) | 5056 | 68.01 (65.43-70.6) | 21.12 (18.84-23.4) | 10.87 (9.17-12.57) |
| | 7–11 years | | 45.62 (40.79-50.45) | 28.76 (24.26-33.25) | 25.62 (21.53-29.71) | | 80.66 (77.46-83.87) | 13.25 (10.55-15.95) | 6.09 (4.08-8.1) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ≥12 years | | 48.17 (43.57-52.78) | 25.57 (21.88-29.25) | 26.26 (22.27-30.25) | | 81.09 (78.28-83.9) | 12.57 (10.58-14.55) | 6.34 (4.06-8.62) |
| Wealth Index | Lowest Quintile | 4670 | 31.29 (27.75-34.83) | 35.13 (31.29-38.98) | 33.58 (29.7-37.46) | 4813 | 78.5 (75.15-81.85) | 13.82 (11.21-16.43) | 7.68 (5.39-9.97) |
| | Lower-Middle Quintile | | 35.35 (30.81-39.89) | 25.47 (21.76-29.18) | 39.18 (34.58-43.79) | | 73.86 (69.77-77.94) | 17.95 (14.34-21.57) | 8.19 (5.73-10.65) |
| | Middle Quintile | | 38.15 (34.42-41.89) | 29.79 (26.23-33.36) | 32.05 (28.53-35.58) | | 76.8 (73.57-80.02) | 15.88 (13.13-18.62) | 7.33 (5.38-9.28) |
| | Upper-Middle Quintile | | 36.66 (32.27-41.05) | 31.46 (27.36-35.55) | 31.88 (27.89-35.87) | | 76.87 (73.6-80.15) | 15.19 (12.59-17.78) | 7.94 (5.63-10.25) |
| | Highest Quintile | | 40.61 (34.8-46.42) | 31.91 (26.88-36.94) | 27.48 (22.71-32.25) | | 72.76 (68.16-77.37) | 18.27 (14.81-21.72) | 8.97 (5.11-12.83) |
| Insurance Coverage | None | 4875 | 45.93 (37.87-53.99) | 32.15 (24.71-39.58) | 21.92 (16.44-27.41) | 5036 | 82.65 (77.77-87.52) | 13.04 (8.77-17.32) | 4.31 (1.81-6.81) |
| | Basic | | 41.64 (38.97-44.3) | 29.28 (26.99-31.57) | 29.08 (26.84-31.33) | | 79.06 (77.1-81.02) | 13.7 (12.22-15.19) | 7.23 (5.76-8.71) |
| | Basic-complementary | | 28.93 (25.85-32) | 33.34 (30.14-36.54) | 37.74 (34.36-41.11) | | 66.36 (62.63-70.08) | 22.56 (19.37-25.75) | 11.08 (8.34-13.83) |
| Physical Activity | Insufficient | 4898 | 37.57 (34.66-40.47) | 31.78 (29.12-34.43) | 30.66 (28.05-33.26) | 5056 | 76.89 (74.33-79.44) | 15.03 (13.01-17.05) | 8.08 (6.22-9.95) |
| | Sufficient | | 37.3 (34.53-40.06) | 29.97 (27.5-32.44) | 32.73 (30.16-35.3) | | 75.78 (73.56-78) | 16.41 (14.64-18.18) | 7.81 (6.22-9.41) |
| Alcohol Consumption | Never Drank | 4884 | 37.57 (35.57-39.57) | 31.14 (29.29-32.98) | 31.3 (29.46-33.13) | 5057 | 77.09 (75.36-78.83) | 15.45 (14.07-16.83) | 7.46 (6.2-8.71) |
| | Former Drinker | | 43.32 (22.65-63.98) | 20.75 (9.13-32.37) | 35.93 (20.16-51.71) | | 54.92 (46.22-63.62) | 30.88 (22.56-39.2) | 14.2 (8.73-19.67) |
| | Current Drinker | | 31.29 (17.75-44.82) | 25.23 (12-38.46) | 43.48 (27.97-59) | | 77.04 (68.89-85.18) | 11.14 (5.88-16.4) | 11.82 (5.14-18.51) |
| Tobacco Use | Never Smoked | 4924 | 37.47 (34.95-39.99) | 33.06 (30.61-35.51) | 29.47 (27.18-31.76) | 5087 | 80.03 (77.82-82.24) | 14.87 (13.08-16.66) | 5.1 (3.57-6.63) |
| | Passive Exposure | | 46.09 (42.02-50.16) | 29.3 (25.97-32.64) | 24.6 (21.08-28.13) | | 85.12 (82.5-87.74) | 11.47 (9.07-13.87) | 3.4 (2.18-4.63) |
| | Former Smoker | | 32.18 (23.68-40.68) | 25.98 (19.61-32.35) | 41.84 (33.89-49.79) | | 65.54 (56.89-74.2) | 23.64 (16.83-30.45) | 10.81 (2.84-18.78) |
| | Current Smoker | | 22.04 (15.09-28.99) | 24.8 (19.6-30) | 53.16 (46.45-59.86) | | 52.93 (48.16-57.71) | 23.24 (19.59-26.89) | 23.83 (19.7-27.96) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Daily Fruit & Vegetable Intake | Insufficient | 4920 | 37.62 (35.42-39.81) | 30.43 (28.47-32.39) | 31.96 (29.95-33.96) | 5083 | 76.55 (74.74-78.36) | 15.67 (14.25-17.1) | 7.77 (6.45-9.1) |
| | Sufficient | | 35.53 (31.04-40.02) | 34 (29.41-38.58) | 30.47 (26.18-34.77) | | 74.86 (70.63-79.09) | 16.64 (13.06-20.22) | 8.5 (5.67-11.33) |
| BMI | Normal/Underweight | 4920 | 35.3 (30.99-39.61) | 26.71 (23.15-30.28) | 37.99 (33.99-41.99) | 5083 | 72.53 (69.34-75.72) | 17.54 (14.96-20.12) | 9.93 (7.54-12.31) |
| | Overweight | | 34.83 (31.79-37.87) | 32.57 (29.53-35.61) | 32.6 (29.63-35.57) | | 76.96 (74.46-79.47) | 15.94 (13.9-17.98) | 7.1 (5.4-8.8) |
| | Obese | | 41.38 (38.07-44.68) | 30.88 (28.1-33.65) | 27.75 (24.93-30.57) | | 79.81 (76.79-82.82) | 13.48 (11.22-15.73) | 6.72 (4.4-9.03) |
| WC | Normal | 4924 | 35.3 (31.91-38.69) | 28.01 (24.87-31.15) | 36.69 (33.45-39.94) | 5087 | 71.74 (69.12-74.36) | 17.81 (15.78-19.84) | 10.45 (8.41-12.49) |
| | High | | 38.52 (36.04-40.99) | 32.15 (29.94-34.37) | 29.33 (27.12-31.54) | | 81.05 (79.06-83.04) | 13.73 (12.04-15.42) | 5.22 (4.02-6.42) |
| Hypertension status | Untreated | 4924 | 48.35 (45.41-51.29) | 28.15 (25.66-30.63) | 23.51 (21.01-26) | | | | |
| | Treated-Uncontrolled | | 13.68 (11.35-16.01) | 32.62 (29.3-35.94) | 53.7 (50.26-57.13) | | | | |
| | Treated-Controlled | | 40.96 (36.58-45.35) | 35.47 (31.32-39.61) | 23.57 (19.9-27.25) | | | | |
| Diabetes status | Normal | 4924 | 58.19 (53.58-62.79) | 26.62 (22.77-30.47) | 15.2 (11.58-18.81) | 5087 | 88.78 (87.06-90.5) | 8.18 (6.69-9.67) | 3.04 (2.16-3.92) |
| | Prediabetic | | 43.66 (40.89-46.44) | 33.3 (30.67-35.92) | 23.04 (20.79-25.28) | | 77.23 (74.89-79.56) | 15.86 (14-17.72) | 6.92 (5.23-8.61) |
| | Diabetic | | 11.76 (8.75-14.76) | 29.84 (26.64-33.03) | 58.41 (54.77-62.05) | | 37.15 (31.99-42.3) | 37.33 (32.08-42.58) | 25.52 (20.16-30.88) |
| Dyslipidemia | No | 4922 | 47.13 (41.6-52.66) | 26.46 (21.66-31.26) | 26.41 (21.9-30.92) | 5083 | 78.6 (75.09-82.11) | 16.36 (13.14-19.59) | 5.03 (3.37-6.69) |
| | Yes | | 35.97 (33.83-38.12) | 31.47 (29.52-33.42) | 32.56 (30.57-34.55) | | 75.73 (73.84-77.62) | 15.67 (14.22-17.12) | 8.6 (7.15-10.04) |

BMI = Body Mass Index; WC = waist circumference; CI = Confidence Interval.

N indicates the number of participants with non-missing data for each variable in the hypertensive and prehypertensive groups.

Data are presented as weighted percentages with 95% confidence intervals.

Framingham Risk Score (FRS) categories were defined as follows: low risk for cardiovascular disease if the 10-year risk was less than 10%, moderate risk if between 10% and 20%, and high risk if greater than 20%.

**Table 3.** Mean values of cardiometabolic indicators among hypertensive and prehypertensive individuals, stratified by cardiovascular disease (CVD) status.

| Variable | Hypertensive Group | | Prehypertensive Group | |
|---|---|---|---|---|
| | CVD-Negative | CVD-Positive | CVD- Negative | CVD- Positive |
| Body Mass Index (kg/m²)† | 28.82 (28.69-28.96) | 29.13 (28.8-29.45) | 26.96 (26.85-27.08) | 27.14 (26.68-27.61) |
| Waist Circumference (cm)† | 98.94 (98.61-99.27) | 101.32 (100.54-102.1) | 93.14 (92.85-93.44) | 97.05 (95.57-98.54) |
| Diastolic Blood Pressure (mmHg)† | 87.36 (87.07-87.66) | 82.77 (81.99-83.55) | 78.44 (78.3-78.58) | 77.75 (77.13-78.36) |
| Systolic Blood Pressure (mmHg)† | 145.38 (144.93-145.83) | 143.8 (142.59-145.01) | 124.62 (124.46-124.78) | 126.38 (125.66-127.1) |
| HDL-C (mg/dL)† | 41.87 (41.5-42.25) | 40.35 (39.59-41.11) | 42.16 (41.77-42.55) | 40.23 (38.7-41.76) |
| LDL-C (mg/dL)† | 102.92 (101.53-104.32) | 86.47 (83.41-89.54) | 101.6 (100.46-102.75) | 89.57 (83.58-95.56) |
| Total Cholesterol (mg/dL)† | 178.32 (176.74-179.91) | 158.2 (154.51-161.89) | 174.26 (172.95-175.57) | 159.82 (153.26-166.39) |
| Triglycerides (mg/dL)† | 168.08 (164.12-172.03) | 156.88 (150.7-163.06) | 152.86 (149.76-155.96) | 150.11 (139.39-160.84) |
| Fasting Blood Sugar (mg/dL)† | 113.13 (111.72-114.55) | 126.3 (121.99-130.61) | 102.17 (101.04-103.31) | 115.01 (109.25-120.77) |
| HbA1c (%)† | 6.34 (6.29-6.39) | 6.88 (6.74-7.02) | 5.87 (5.83-5.92) | 6.45 (6.27-6.63) |

CVD, cardiovascular disease; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; HbA1c, glycated hemoglobin.

Variables are presented as weighted means with 95% confidence intervals. All other values represent weighted percentages with 95% CIs.

## Figures

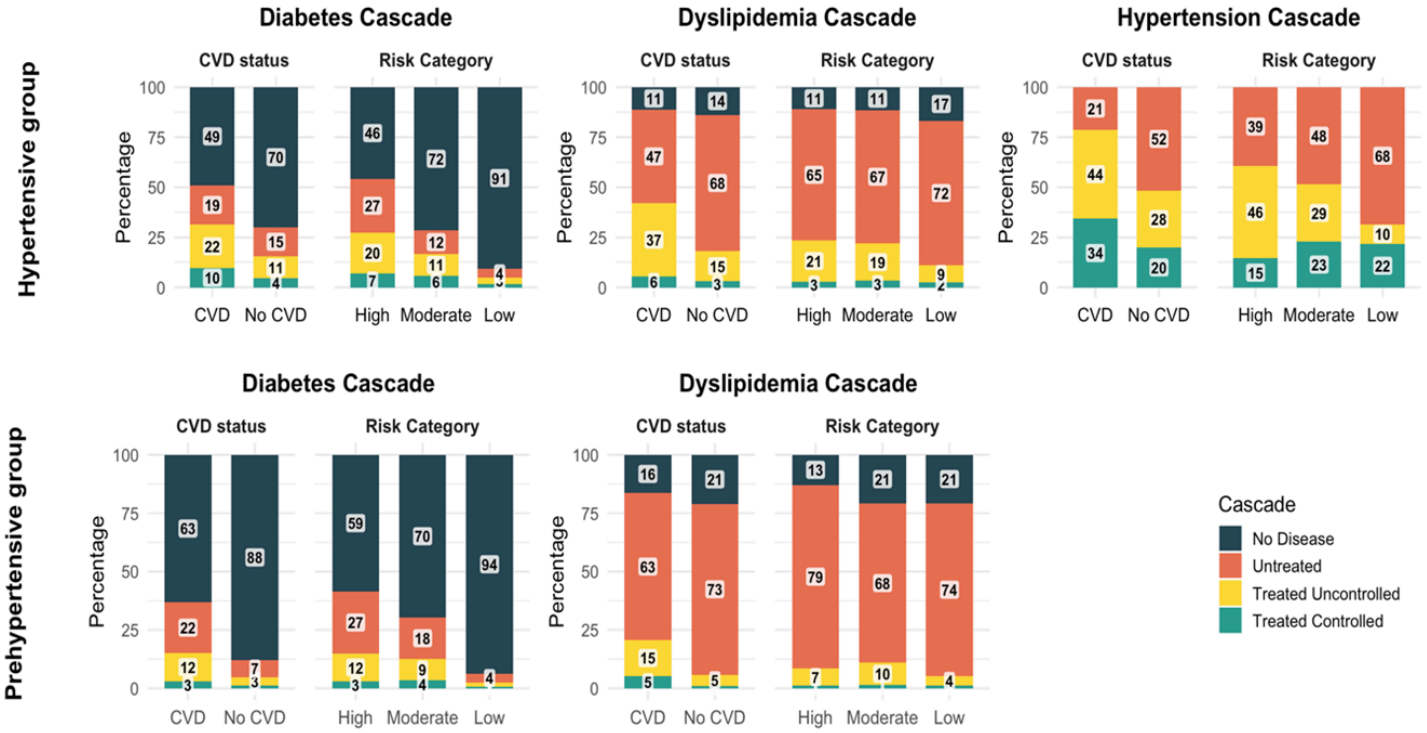



**Figure 1**

**Cascades of Care for Diabetes, Dyslipidemia, and Hypertension by CVD Status and Framingham Risk Category.**
Percentages of hypertensive and prehypertensive individuals stratified by CVD status and Framingham risk categories, showing proportions with no disease, untreated, treated but uncontrolled, and treated/controlled conditions.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTable1.docx