Prevalence of cardiovascular disease risk factors and long-term outcomes in the Saudi population: Results from the Prospective Urban Rural Epidemiology study (PURE-Saudi)

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Abstract

Objective We report the prevalence of unhealthy lifestyle behaviors, cardiovascular disease (CVD) risk factors, and long-term outcomes within the Saudi population, stratified by age, sex, and place of residence.

Methods The Prospective Urban Rural Epidemiology (PURE) study is a global cohort study including adults of 35–70 years old in 20 countries. PURE-Saudi study participants were recruited from 19 urban and 6 rural communities randomly selected from the Central province (Riyadh and Alkharj) between February 2012 and January 2015. Clinical follow-up of major CVD events and mortality is ongoing.

Results The PURE-Saudi study enrolled 2047 participants (mean age, 46.5 ± 9.12 years; 43.1% women; 24.5% rural). Overall, 69.4% had low physical activity, 49.6% obesity, 34.4% unhealthy diet, 32.1% dyslipidemia, 30.3% hypertension, 25.1% diabetes, 12.2% were current smokers, 15.4% self-reported feeling sad, 16.9% had history of stress (several periods), 6.8% had permanent stress, 0.98% had history of stroke, 0.64% had heart failure, and 2.5% had coronary heart disease (CHD). Compared to women, men were more likely to be current smokers (21% vs. 0.45%, $p<0.001$), have diabetes (28.2% vs. 21.3%, $p<0.001$), and have history of CHD (3.2% vs. 1.6%, $p=0.02$); while women were more likely to be obese (58.6% vs. 42.8%, $p<0.001$), have central obesity (70.7% vs. 32.7%, $p<0.001$), self-report sadness (22.7%, vs. 9.9% $p<0.001$), experience stress (several periods), feel permanent stress (9.9% vs. 4.5%, $p<0.001$), and have low education (46.6% vs. 20.2%, $p<0.001$). Compared to participants in urban areas, those in rural areas had higher rates of diabetes (31.1% vs. 23.3%, $p<0.001$), obesity (56.6% vs. 47.3%, $p<0.001$), and hypertension (35.5% vs. 28.6%, $p=0.004$); and lower rates of unhealthy diet, self-reported sadness, stress (several periods), and permanent stress. Compared to middle- and old-age individuals, younger participants more commonly reported unhealthy diet, permanent stress, and self-reporting of being sad.

Conclusion PURE-Saudi, the first population cohort study in Saudi Arabia, revealed a high prevalence of CVD risk factors in the adult Saudi population, with higher rates in rural than urban areas. National public awareness programs and multi-faceted healthcare policy changes are urgently needed to reduce the burden of CVD risk and mortality.

Introduction

Cardiovascular diseases (CVD) are the leading causes of mortality worldwide, contributing to 31% of all deaths [1]. CVD is also becoming a major health concern in the Gulf Council Countries (GCC) including Saudi Arabia, as it is estimated that the overall deaths from CVD account for over 45% of all deaths [1, 2]. The most common CVD risk factors were identified in the INTERHEART and INTERSTROKE studies were hypertension, diabetes, dyslipidemia, obesity, smoking, physical activity, poor diet, and alcohol consumption [3, 4]. In the Gulf countries, lifestyle has changed dramatically due to the rapid urbanization with an increase in the poor diet and the adoption of a sedentary lifestyle. Consequently, the rates of CVD risk factors and the chronic non-communicable diseases among the Gulf population are also high [2,5-32].

The Prospective Urban Rural Epidemiology (PURE) study is a prospective cohort study that aimed to collect data on social, environmental, and individual CVD risk factors and chronic diseases in high-, middle-, and low-income countries [33]. Saudi Arabia has been classified as high-income country and joined the global PURE study in 2012. The current PURE Saudi report focuses mainly on assessing the demographics, unhealthy lifestyle and the prevalence of CVD risk factors, stratified age, sex, and place of residence (urban vs rural). Given the relatively small sample size at this stage, we have only reported the absolute number of cases diagnosed with cancer, myocardial infarction, stroke, heart failure, and death over a median (IQR) duration of follow-up duration of 3.4 (3.2-6.1) years.

Methods

Study design and participants

The study design, methods (including sampling, information gathered, and follow-up strategy), and participant characteristics of the PURE study have been published previously [33-36]. Briefly, adults aged between 35 years and 70 years from 367 urban and 302 rural communities in 20 countries were included. Households were eligible if one or more of the households' members was aged between 35 and 70 years and the household members intended to stay at that address for a further four years. Risk factors and medical history were documented, and a physical examination was performed on subjects who provided written informed consent. Details of sampling, information gathered, and follow-up strategy have been previously reported in several publications [34, 35].

Procedures

Data regarding the demographic factors, socioeconomic status, medical history, health behaviors (e.g., smoking, physical activity, diet, alcohol intake), and subjects' household members were collected by using standardized questionnaires. Low education was defined as no education, primary education only or unknown educational level. Diet quality was determined on the basis of the Alternative Healthy Eating Index, which ranges from 6 to 70, with higher scores indicating more healthful eating. An unhealthful diet was considered to be a score of less than 31. In addition, we collected information regarding psychosocial factors (feeling blue and general stress) and other CVD risk factors such as hypertension, diabetes and obesity as described in the INTERHEART study [3]. We defined stress in terms of reporting stress over several periods, and having permanent stress. Operationally, stress is defined as feeling irritable or felt with anxiety, or as having sleeping difficulties as a result of conditions at work or at home. It was categorized into 1-None- little 2-Moderate 3- High-severe.

The questionnaire also asked about anthropometric measures, including weight, height, body mass index, waist circumferences and blood pressure. Physical activity was measured using the International

Physical Activity Questionnaire (IPAQ) and was categorized according to the metabolic equivalent of task (MET) per min per week into low (3000 MET min per week) activity.

Subjects were considered to have diabetes if a physician had previously diagnosed them with diabetes and/or if they had a fasting plasma glucose level of ≥126 mg/dl (7.0 mmol/l) or were being treated with glucose-lowering medication. Subjects with history of hypertension, current use of antihypertensive medication and/or a blood pressure ≥ 140 (systolic) or ≥ 90 (diastolic) mm Hg were considered to have hypertension. All subjects were asked whether they had a medical diagnosis of hypertension (awareness) and whether they were receiving antihypertensive medication (treatment). Hypertension control was defined as the proportion of subjects with an average systolic and diastolic blood pressure of < 140/90 mm Hg. Blood pressure was measured two times at sitting position from the right arm following a standardized procedure using an Omron digital blood pressure measuring device (Omron HEM-757; Omron Healthcare, Kyoto, Japan) provided for all sites. A total cholesterol level > 5.2 mmol/l (201 mg/dl) was considered to be an elevated level. Major CVD (myocardial infarction or angina, stroke or heart failure) were the main clinical outcomes included in the analyses based on subjects self-reported responses. We assessed CVD risk using the INTERHEART Risk score, which is a validated score for quantifying risk-factor burden without the use of laboratory testing. Scores range from 0 to 48, with higher scores indicating greater risk-factor burden.

PURE Saudi

Recruitment of Saudi individuals for the PURE study was carried out between February 2012 and January 2015. Nineteen urban and six rural communities were enrolled from the city of Riyadh and Alkharj (Central province). Urban communities involved were defined according to the governmental geographic distribution of the districts, while rural communities were defined as those regions located at least 50 km away from the center of Riyadh. Due to cultural acceptance, the study team met the participants in the primary health care centers (PHCC) in each community. The database of each PHCC was screened and the eligible subjects were randomly invited to participate in the study by calling and/or sending them a short text message service to their mobile phones. A target number of at least 50 subjects were required to be enrolled per each PHCC. All subjects were encouraged to invite their eligible family members who were living within the same household. All blood samples were shipped to the laboratory in the King Khalid University Hospital at King Saud University, Riyadh. Subsequently, the blood results were returned to the treating physicians at the PHCC for further assessment and management.

During the follow-up period, the study team conducted a reminder call at 18 months after the baseline recruitment by telephone to remind the subjects about their upcoming follow-up at 3, 6, and 9 years. During a median (IQR) duration of follow-up duration of 3.4 (3.2-6.1) years, the study team recorded death, cancer, myocardial infarction, stroke, or heart failure based on self-reports from the participant or a family member. Incidence rates were then calculated taking into account the duration of follow-up and time to the corresponding events.

Statistical analysis

Total number of subjects recruited in this study was using convenient sampling based on the real-life acceptance rates from the community, and at the same time to have a reasonable representation of subjects in the communities in the Riyadh region. We have summarized categorical variable with frequency and percentages but for continuous variables we have summarized means and standard deviations (SD) or median and inter-quartile ranges (IQR). We have compared proportion of participants in different groups using Chi-square test or Fisher's exact test for categorical variables. However, for continuous variables we have used student t-test or Mann Whitney u test for two groups and the analysis of variance or Kruskal-Wallis Test for more than two groups. Age was categorized into three groups: 35-49 years, 50-59 years and 60-70 years. Education was categorized as high (i.e., trade school, college or university); medium (i.e. secondary school or high school), low (i.e, primary education or no education) or unknown. We have also calculated the Incidence rate of events taking into account the duration of follow-up and time to the corresponding events in 100-person years. All Statistical analysis were performed using SAS version 9.2 (SAS Institute, Inc, Cary, NC). A P value of less than 0.05 was considered statistically significant.

Human Subject Protection

King Saud University Ethics Committee granted ethical approval to this. Participation in the study was voluntary and all eligible subjects who provided written informed consent were enrolled.

Results

Overall cohort

The PURE-Saudi study enrolled 2047 participants, with mean age of 46.5±9.12 years (Table 1). There were 1165 men (56.9%) and 882 women (43.1%). Around one third of the total cohort had low educational level.

CVD risk factors

The mean body mass index (BMI) of the participants was 30.6, where majority of them were either overweight (35.3%) or obese (49.6%). Among obese patients, 30% had BMI between 30-35, and 19.5% had BMI > 35. The prevalence of abdominal obesity defined as waist circumference >102 cm (men) or >88 cm (women) was 49%. This prevalence is increased to 74.3% when the measured waist circumference >90 cm (men) or >85 cm (women).

The prevalence of hypertension was 30.3%, out of which only 61.1% were aware of it, 58.9% were treated and 30.7% participants achieved blood pressure control.

The prevalence of diabetes was 25.1%, out of which 2.7% were on insulin therapy, 60.7% received oral hypoglycemic agents (OHA), 6.6% received both (insulin and OHA), and 30% received no treatment. About one third (32.1%) had high total cholesterol level, however, history of stroke was found in 0.98%, heart failure in 0.64%, and coronary heart disease in 2.5%. In addition, the median INTERHEART risk score was 11.

Health behaviors and psychosocial factors

Approximately 34.4% of the total cohort reported eating unhealthy diet, 69.4% of participants reported low physical activity, 12.2% were current smokers, and 10.6% were former smokers. Moreover, the prevalence of self-reported of being sad or blue was 15.4%, while 16.9% had reported history of several feeling of stress and 6.8% had permanent feeling of stress.

Men vs Women

Compared to women, men have significantly higher proportion of current smoking (21% vs 0.45%, $p<0.001$) or former smoking (17.9% vs 0.91%, $p<0.001$), diabetes (28.2% vs 21.3%, $p<0.001$), obesity with BMI 30-35 (39.9% vs 32.4%, $p<0.001$), history of ischemic heart disease (3.2% vs 1.6%, $p=0.02$), and the median INTERHEART risk score (13% vs 10%, $p<0.001$). On the other hand, women had higher prevalence of obesity with BMI > 35 (26.1% vs 14.5%, $p<0.001$), central obesity (70.7% vs 32.7%, $p<0.001$), self-reporting of being sad (22.7%, vs 9.9% $p<0.001$), several feeling of stress (23.1% vs 12.4%, $p<0.001$) or permanent feeling of stress (9.9% vs 4.5%, $p<0.001$), and low level of education (46.6% vs 20.2%, $p<0.001$) (Table 1 and Figure A).

The awareness, treatment, and control of blood pressure were similar among women and men (61.3% vs 60.9%, 60.9% vs 57.6%, 34.5% vs 28.3%, ($P =0.93$, $P =0. 41$, $P =0.10$)) respectively. In addition, men were more likely to have lower HDL-cholesterol levels compared with women (Additional Table 1).

Table 1. Characteristics and the prevalence of cardiovascular disease risk factors; in the PURE-Saudi study.

Characteristics	Overall	Men	Women	p-value[1]
N (%)	2047	1165 (56.91)	882 (43.09)	
Demographics				
Age (year), mean ± SD	46.50 ± 9.12	47.55 ± 9.40	45.10 ± 8.55	< 0.001
Low educational level, n (%) †	646 (31.56)	235 (20.17)	411 (46.60)	< 0.001
Behavioral risk factors				
Smoking status, n (%) ‡				
Current smoker	249 (12.16)	245 (21.03)	4 (0.45)	< 0.001
Former smoker	217 (10.60)	209 (17.94)	8 (0.91)	< 0.001
Unhealthful diet, n (%) §	702 (34.39)	397 (56.55)	305 (43.45)	0.827
Low physical activity, n (%) ¶	1415 (69.40)	805 (69.34)	610 (69.48)	0.946
Current alcohol use, n (%)	24 (1.17)	24 (2.06)	0 (0.00)	< 0.001
Hypertension				
Hypertension, n (%) ◊	620 (30.29)	382 (32.79)	238 (26.98)	0.005
Awareness among known hypertensive patients, n (%)	379 (61.13)	233 (60.99)	146 (61.34)	0.931
Treated hypertension among known hypertensive patients, n (%)	365 (58.87)	220 (57.59)	145 (60.92)	0.412
Controlled (ie SBP < 140 mm Hg) among those known to be hypertensive patients, n (%)	190 (30.65)	108 (28.27)	82 (34.45)	0.104
Treated hypertension and SBP ≥ 140 mmgH and/or DBP ≥ 90mmgH, n (%)	175 (47.95)	112 (50.91)	63 (43.45)	0.163
Treated hypertension and SBP > 120 mmgH and/or DBP > 80 mmgH, n (%)	318 (87.12)	198 (90)	120 (82.76)	0.043
Treated hypertension and SBP > 130 mmgH and/or DBP > 80 mmgH, n (%)	272 (76.19)	173 (79.36)	99 (71.22)	0.078
Diabetes				
Diabetes, n (%) **	516 (25.21)	328 (28.15)	188 (21.32)	< 0.001
Among diabetic patients				0.093
On insulin alone	14 (2.71)	5 (1.52)	9 (4.79)	
On OHA alone	313 (60.66)	200 (60.98)	113 (60.11)	
on both	34 (6.59)	19 (5.79)	15 (7.98)	
not on drug treatment	155 (30.04)	104 (31.71)	51 (27.13)	
Dyslipidemia				
Total Cholesterol > 5.2 mmol/L and LDL > 3.5 mmol/L, n (%)	569 (32.1)	234 (31.2)	335 (32.68)	0.508
Obesity				
BMI, mean	30.6 ± 5.9	29.7 ±5.4	31.9 4 ± 6.3	< 0.001
BMI, n (%) ††				< 0.001

Characteristics	Overall	Men	Women	p-value[1]
< 25	310 (15.15)	205 (17.60)	105 (11.92)	
25-30	722 (35.29)	462 (39.66)	260 (29.51)	
31-35	613(29.96)	463(39.78)	286(32.43)	
> 35	399 (19.50)	169 (14.52)	230 (26.08)	
Abdominal obesity, n (%)				
Waist circumference > 102 cm (men) or > 88 cm (women)	1005 (49.1)	381 (32.7)	624 (70.75)	< 0.001
Waist circumference > 90 cm (men) or > 85 cm (women)	1521 (74.3)	835 (71.67)	686 (77.78)	0.002
Psychosocial				
Self-report of being sad or "blue", n (%)	315 (15.40)	115 (9.88)	200 (22.68)	< 0.001
General feeling of stress, n (%)				
Several periods	339 (16.93)	143 (12.40)	196 (23.09)	< 0.001
Permanent	136 (6.79)	52 (4.51)	84 (9.89)	< 0.001
Medical History				
History of ischemic heart disease (angina, MI or any coronary revascularization), n (%)	51 (2.49)	37 (3.18)	14 (1.59)	0.022
History of stroke, n (%)	20 (0.98)	12 (1.03)	8 (0.91)	0.779
History of heart failure, n (%)	13 (0.64)	5 (0.43)	8 (0.91)	0.178
INTERHEART Risk Score, median (25th-75th, IQR)	11.00 (8.00,16.00)	13.00 (9.00,18.00)	10.00 (6.00,14.00)	< 0.001

[1] P-values refer to the results of either chi-square tests (for categorical variables) or t-tests (for continuous variables comparing the mean between categories.

Young vs Middle vs Old age

Compared to the younger and middle age groups (35-49 years and 50-59 years), older participants (60-70 years) had higher prevalence of low physical activity (75.2% vs 66.8% and 73.9% , p=0.002), hypertension (65% vs 18.2% and 48.4%, p <0.001), diabetes (57.5% vs 12.9% and 44.9%, p<0.001), low level of education (62.8% vs 21.7% and 44.9%, p<0.001), stroke (3.9% vs 0.4% and 1.1%, p<0.001), history of heart failure (1.8% vs 0.15% and 1.5%, p<0.001), and history of ischemic heart disease (7.5% vs 1.1% and 4.1%, p<0.001) (Table 2 and Figure B). The awareness and treatment of blood pressure were higher among older participants compared with middle and younger individuals (73.5% vs 70.04% and 45.5%, 73.5% vs 69.2% and 40.7%, P < 0.0001 for all).

While, middle age participants had more controlled of blood pressure compared to young and older individuals (39.2% vs 19.9% and 35.4%, P < 0.0001). However, younger age groups reported more consumption of unhealthy diet (38.9% and 25.2% vs 26.5%, $p<0.001$), general feeling of permanent stress (9.1% and 2.4% vs 1.9%, $p<0.001$), and self-reporting of being sad (18.6% and 10% vs 7.1%, $p<0.001$). The prevalence of obesity with BMI 30-35 and BMI >35 was 34.1% and 21.8% in the middle age group compared to 28.7% and 19.4% in the young age, and 28.8% and 15.5% in older age groups (0.001) respectively. Moreover, the median level of glucose and triglycerides were significantly increased with advanced age (Additional Table 2).

Table 2. Prevalence of cardiovascular disease risk factors stratified by age groups in the PURE-Saudi study.

Characteristics	35-49 yrs	50-59 yrs	60-70 yrs	p-value[1]
N (%)	1352 (66.05)	469 (22.91)	226 (11.04)	
Demographics				
Low educational level, n (%)	293 (21.67)	211 (44.99)	142 (62.83)	< 0.001
Behavioral risk factors				
Smoking status, n (%)				
Current smoker	181 (13.39)	48 (10.23)	20 (8.85)	0.054
Former smoker	124 (9.17)	60 (12.79)	33 (14.60)	0.011
Unhealthful diet, n (%)	524 (38.90)	118 (25.21)	60 (26.55)	< 0.001
Low physical activity, n (%)	899 (66.84)	346 (73.93)	170 (75.22)	0.002
Current alcohol use, n (%)	14 (1.04)	7 (1.49)	3 (1.33)	0.632
Hypertension				
Hypertension, n (%)	246 (18.20)	227 (48.40)	147 (65.04)	< 0.001
Aware among known hypertensive patients, n (%)	112 (45.53)	159 (70.04)	108 (73.47)	< 0.001
Treated hypertension among known hypertensive patients, n (%)	100 (40.65)	157 (69.16)	108 (73.47)	< 0.001
Controlled among known hypertensive patients, n (%)	49 (19.92)	89 (39.21)	52 (35.37)	< 0.001
Treated hypertension and SBP ≥ 140 mmgH and/or DBP ≥ 90 mmgH, n (%)	51 (51.00)	68 (43.31)	56 (51.85)	0.304
Treated hypertension and SBP > 120mmgH and/or DBP > 80mmgH, n (%)	86 (86.00)	135 (85.99)	97 (89.81)	0.609
Treated hypertension and SBP > 130 mmgH and/or DBP > 80 mmgH, n (%)	80(80.81)	115(73.72)	77(75.49)	0.423
Diabetes				
Diabetes, n (%)	175 (12.94)	211 (44.99)	130 (57.52)	< 0.001
Among diabetic patients				0.831
On insulin alone	5 (2.86)	6 (2.84)	3 (2.31)	
On OHA alone	105 (60.00)	130 (61.61)	78 (60.00)	
on both	12 (6.86)	10 (4.74)	12 (9.23)	
not on drug Rx	53 (30.29)	65 (30.81)	37 (28.46)	
Dyslipidemia				
Total Cholesterol > 5.2 mmol/L and LDL > 3.5 mmol/L, n (%)	380 (32.45%)	124 (29.95%)	65 (34.21%)	0.514
Obesity				
BMI, mean	30.6 ± 6.03	31.4 ± 5.53	29.5 ± 5.7 4	0.003
BMI, n (%)				< 0.001
< 25.0	211 (15.62)	46 (9.81)	53 (23.45)	
25.0-30.0	488 (36.12)	161 (34.33)	73 (32.30)	
30.1- 35.0	388 (28.72)	160 (34.12)	65 (28.76)	
> 35.0	262(19.39)	102(21.75)	35(15.49)	
Abdominal obesity, n (%)				

Characteristics	35-49 yrs	50-59 yrs	60-70 yrs	p-value[1]
Waist circumference > 102 cm (men) or > 88 cm (women)	628 (46.45)	262 (55.86)	115 (50.88)	0.002
Waist circumference > 90 cm (men) or > 85 cm (women)	960 (71.01)	389 (82.94)	172 (76.11)	< 0.001
Psychosocial				
Self-report of being sad or “blue”, n (%)	252 (18.65)	47 (10.02)	16 (7.08)	< 0.001
General feeling of stress, n (%)				
Several periods	249 (18.64)	74 (16.30)	16 (7.55)	< 0.001
Permanent	121 (9.06)	11 (2.42)	4 (1.89)	< 0.001
Medical History				
History of ischemic heart disease (angina or MI), n (%)	15 (1.11)	19 (4.05)	17 (7.52)	< 0.001
History of stroke, n (%)	6 (0.44)	5 (1.07)	9 (3.98)	< 0.001
History of heart failure, n (%)	2 (0.15)	7 (1.49)	4 (1.77)	<0.001
INTERHEART Risk Score, median (25th-75th, IQR)	10.00 (7.00,14.00)	14.00 (10.00,19.00)	16.00 (12.00,21.00)	< 0.001

[1] P-values refer to the results of either chi-square tests (for categorical variables) or analysis of variance (for continuous variables comparing the mean across categories.

Urban vs Rural

Participants living in urban areas represented 75.48% of the participants, while 24.5% lived in rural areas. Compared to urban areas, participants living in rural areas reported higher prevalence of diabetes (31.1% vs 23.3%, p<0.001), obesity (56.6% vs 47.3%, p<0.001), hypertension (35.5% vs 28.6%, p=0.004), and low level of education (46.4% vs 26.7%, p<0.001). In addition, the median BMI was higher among rural compared to urban participants (30.8% vs 29.7%, p<0.001).On the other hand, urban participants more likely to consume unhealthy diet (36% vs 29.4%,p=0.007), to self-report of being sad (17.6% vs 8.6%, p<0.001), to have several feeling of stress (19.7% vs 8.7%, p<0.001), and permanent feeling of stress (8.03% vs 3.02% p<0.001) (Table 3 and Figure C).

The awareness, treatment, and control of blood pressure were similar among the urban and rural communities (62.2% vs 58.4%, 60.1% vs 55.6%, 32.6% vs 25.8%, (P =0.38, P =0. 29, P =0.10) respectively. Furthermore, urban participants showed higher median in the glucose level and proportion in the glucose level between 6-7 mmol/L in non-diabetic patients (Additional Table 3).

Table 3. Prevalence of cardiovascular disease risk factors stratified by place of residence in the PURE-Saudi study.

Characteristics	Urban	Rural	p-value
N (%)	1545 (75.48)	502 (24.52)	
Demographics			
Age (year), mean ± SD	46.31 ± 8.88	47.07 ± 9.81	0.124
Low educational level, n (%)	413 (26.73)	233 (46.41)	< 0.001
Behavioral risk factors			
Smoking status, n (%)			
Current smoker	198 (12.82)	51 (10.16)	0.114
Former smoker	175 (11.33)	42 (8.37)	0.061
Unhealthful diet, n (%)	556 (36.01)	146 (29.38)	0.007
Low physical activity, n (%)	1061 (68.72)	354 (71.52)	0.240
Current alcohol use, n (%)	18 (1.17)	6 (1.20)	0.956
Hypertension			
Hypertension, n (%)	442 (28.61)	178 (35.46)	0.004
Aware among known hypertensive patients, n (%)	275 (62.22)	104 (58.43)	0.381
Treated hypertension among known hypertensive patients, n (%)	266 (60.18)	99 (55.62)	0.296
Controlled among known hypertensive patients, n (%)	144 (32.58)	46 (25.84)	0.100
Treated hypertension and SBP ≥140mmgH and/or DBP ≥ 90mmgH, n (%)	122 (45.86)	53 (53.54)	0.192
Treated hypertension and SBP > 120mmgH and/or DBP > 80mmgH, n (%)	227 (85.34)	91 (91.92)	0.095
Treated hypertension and SBP > 130 mmgH and/or DBP > 80mmgH, n (%)	191(73.46)	81(83.51)	0.047
Diabetes			
Diabetes, n (%)	360 (23.30)	156 (31.08)	< 0.001
Among diabetic patients			< 0.001
on insulin	11 (3.06)	3 (1.92)	
on OHA	249 (69.17)	64 (41.03)	
on both	31 (8.61)	3 (1.92)	
not on Rx	69 (19.17)	86 (55.13)	
Dyslipidemia			
Total Cholesterol > 5.2 mmol/L and LDL > 3.5 mmol/L, n (%)	439 (31.49%)	130 (34.12%)	0.330
Obesity			
BMI, mean	30.4 ± 5.8	31.4 ± 6.23	0.037
BMI, n (%)			< 0.001
< 25.0	245 (15.87)	65 (12.95)	
25.0-30.0	569 (36.85)	153 (30.48)	
30.1- 35.0	454 (29.39)	159 (31.74)	
> 35.0	275(17.80)	124(24.75)	
Abdominal obesity, n (%)			
Waist circumference > 102 cm (men) or > 88 cm (women)	754 (48.80)	251 (50.00)	0.641
Waist circumference > 90 cm (men) or > 85 cm (women)	1156 (74.82)	365 (72.71)	0.347
Psychosocial			

Characteristics	Urban	Rural	p-value
Self-report of being sad or “blue”, n (%)	272 (17.62)	43 (8.57)	< 0.001
General feeling of stress, n (%)			
Several periods	296 (19.65)	43 (8.67)	< 0.001
Permanent	121 (8.03)	15 (3.02)	< 0.001
Medical history			
History of ischemic heart disease (angina or MI), n (%)	36 (2.33)	15 (2.99)	0.411
History of stroke, n (%)	12 (0.78)	8 (1.59)	0.118
History of heart failure, n (%)	8 (0.52)	5 (1.00)	0.327
INTERHEART Risk Score, median (25th-75th, IQR)	11.00 (8.00,16.00)	12.00 (7.00,17.00)	0.833

Follow-up

A total of 1996 out of 2047 participants responded to follow-up after baseline, resulting in a response rate of 97.5%. Current mean (SD) and median (IQR) duration of follow-up is 4.3 (1.4) and 3.4 (3.2-6.1) years respectively. We have attempted to contact participants for at least three times. There were 6 patients diagnosed with cancer and total of 22 deaths (at rate of 0.07 and 0.26 per 100 person years of follow-up respectively). The overall rates of major cardiovascular events showed similar pattern to that for mortality, where 24 had a myocardial infarction, 6 had a stroke, 4 had heart failure, and 34 had at least one major cardiovascular events with rates of 0.29, 0.07, 0.05, and 0.41 per 100 person years of follow-up respectively.

Discussion

The PURE-Saudi study reports on the prevalence of unhealthy lifestyle behaviors and CVD risk factors, stratified by age, sex, and place of residence. Being part of the internationally standardized and validated surveys of the global PURE study allows for a valid interpretation and direct comparison of the results in the context of other enrolled countries with variable economic scales and health care systems. Our study showed two major findings. First, the high prevalence of CVD risk factors among the Saudi population including two-thirds had low physical activity, half had obesity, one third consumed unhealthy diet, one third had dyslipidemia, one third had hypertension, and one quarter had diabetes. Second, the relative proportion of the individual CVD risk factors varies according to age, sex, and place of residence.

The PURE-Saudi study confirms that the prevalence of un-healthy life styles and CAD risk factors remains high in the Saudi population despite over a decade of several previous population cross-sectional surveys (Additional Table 4), which is consistent with previous work that has demonstrated high prevalence of hypercholesterolemia, obesity, hypertension, diabetes, smoking, physical inactivity, and diabetes in Saudi Arabia The Coronary Artery Disease in the Saudis Study (CADISS) was a national epidemiological health survey between 1995 and 2000, and included 17,395 Saudis aged 30-70 years through a multistage stratified cluster sampling technique. The overall prevalence of hypercholesterolemia was 54%, obesity 35.6%, hypertension 26.1%, diabetes 23.7%, and smoking 12.8% [11-13, 23-25]. Another national cross-sectional survey by the Saudi Ministry of Health involved 4758 participants aged 15 year to 64 year and aimed to estimate the prevalence of some of the risk factors of non-communicable diseases (NCD) by using the WHO STEPwise approach for NCD surveillance. It indicated that the prevalence of physical inactivity was 67.6%, obesity 36.2%, hypercholesterolemia 19.1%, hypertension 11.6%, diabetes 15.3%, and current daily smoking 10.9% [14]. The Saudi Health Information Survey (SHIS) was done also by the Ministry of Health and enrolled 10,735 Saudis aged 15 years or older in 2013.The prevalence of physical inactivity was 39.8%, obesity 28.7%, daily consumption of < 2 servings of fruits and vegetables 61.6%, hypertension 15.2%, diabetes 13.4%, hypercholesterolemia 8.5%, and smoking 12.1% [9, 10, 28, 29, 37]. As a result of such high prevalence of the CVD risk factors, patients in Saudi Arabia present almost a decade younger with acute coronary syndromes and acute heart failure compared to those in the developed countries; hence suffer from being at high risk for cardiovascular complications and mortality [38-40].

Compared to the general population, patients with diabetes are 2 to 4 times more likely to develop CVD [41]. According to the International Diabetes Federation diabetes Atlas (8th edition), Saudi Arabia is among the top ten countries in the prevalence of diabetes mellitus [42]. It is estimated that the diabetes prevalence will increase by 110% in the Middle East and North Africa (MENA) by 2045. The prevalence of diabetes in PURE Saudi was among the highest levels reported in the global PURE data. Overall, diabetes prevalence was 11%, and the prevalence of diabetes varied between country income groups, where prevalence of diabetes was lowest in HICs 6.6% and highest in low-income countries (LICs) 12.3% [43]. Moreover, analysis of the global PURE data showed that hypertension prevalence was 40.8%, and that only third of the patients had reached their blood pressure targets [44]. A report of prevalence, awareness, treatment, and control of hypertension from baseline PURE data from four Middle East countries [Iran, Occupied Palestinian Territory (OPT), Saudi Arabia, and United Arab Emirates (UAE)] showed that one-third had hypertension, about half of them were aware and treated, but only one-fifth were controlled [45]. The prevalence of hypertension was highest in UAE (52%) and lowest in Iran (28%), while the awareness, treatment, and control of hypertension were higher in the OPT and Saudi Arabia, compared with UAE and Iran [45].

Other previous national studies reported suboptimal hypertension control in the Saudi population [7, 24]. Affordability of medications is one of the main reasons for the low rate of hypertension control in the world [46]. However, in Saudi Arabia, healthcare and medications are free of charge, making them largely accessible to the population. Several barriers facing patients, physicians, and healthcare systems pursuing control of hypertension, indicating the need for multifaceted interventions [47, 48]. Forgetting to take medical therapies and medication side effects were important barriers to medication adherence [48]. Analysis data from a large household survey of 10,735 participants to identify barriers to healthcare in Saudi Arabia found that neither distance to nor type of healthcare clinic were barriers to management of chronic diseases, and highlighted the importance to individual's healthcare seeking practices rather than system based as potential barriers. Possibly that some Saudi population have specific healthcare-seeking practices and they mostly seek healthcare when they are sick and that contradict the concept of an old Arab proverb 'Prevention is better than treatment' [49]. Lack of primary care physicians' knowledge and awareness of hypertension guidelines was also found where one-fourth of 322 primary care physicians had deficient knowledge regarding the correct definition of hypertension [50]. Regarding the healthcare systems barriers, inappropriate coordination between medical sectors has been reported as about one third of Saudi hypertensive patients did not have hypertension file at the primary health care centers and they received medical care at different health care sectors that led to missing their regular appointments [47].

One of the main findings of PURE Saudi is that women are more obese compared to men. Possible explanation of higher obesity prevalence in women in this cohort may be due to some sociocultural factors and governmental bylaws such as – only until recently- the requirement of women to have a car driver for transportation purposes and barriers to practice physical activities in public places that could lead to increasing prevalence of sedentary lifestyle and obesity in Saudi women. Therefore, increasing accessibility of women to exercise facilities and providing safe walking areas are likely to help to reduce the obesity prevalence. Recently, women gymnasia in Saudi Arabia became more accessible and women were allowed to drive by themselves, which could potentially help in improving access to a healthier lifestyle. On the other hand, the lower rate of diabetes in women than men in our study may attributed to the well-recognized greater willingness of women than men to seek medical advice [51]. In addition, women are also more willing than men to adhere to diabetes daily management such as restricted diet, blood glucose monitoring, and medication adherence [52].

Another important issue to be highlighted is the common belief that risk of developing CVD is higher in individuals who live in urban areas compared to those in rural areas [53]. Findings from the global PURE cohort from high-income countries reported that similar INTERHEART risk score among population in rural areas in comparison to urban population [35]. However, the PURE Saudi study showed that population living in rural areas had higher CVD risk factors particularly in the prevalence of diabetes, hypertension and obesity compared to the urban population. Possible reasons might be related to 'urbanization of rural life', a term that described by some researchers [54]. where agriculture became mechanized, and cars are used for rural transport, road infrastructure improved, and more consumption of processed carbohydrates and commercially prepared and processed food through national and transnational companies, all of these would contribute to the increase in rural obesity [55-57]. In addition, the limited time and space for cooking healthy meals and possibly perceptions of large weight as a sign of affluence could also exacerbate these effects [57, 58]. Our findings might also reflect less access to and /or low availability of a health care prevention and management facilities in the rural areas. The reason behind these disparities may be due to inconsistent insurance policies, poor healthcare infrastructure and privatization, and accessibility to healthcare facilitates which largely focus on the urban population, leaving the rural population at disadvantage [59]. The higher prevalence of diabetes in rural rather than urban areas provide support for the link between diabetes and lifestyle risk factors (lifestyle changes are less prominent in rural areas). In addition, the lower educational level among rural population as demonstrated in this study may also partly explain the differences in risk factor levels, resembling what was found in the Vasterbotten Intervention Program study in Sweden [60]. For instance, rural population with only primary education level had consistently higher prevalence of hypertension than urban population with higher educational levels [60]. The data form global PURE that assessed socioeconomic status and risk of CVD in 20 low, middle, and high-income countries, education, rather than wealth, was the socioeconomic indicator most consistently associated with outcomes where the major CVD events and all cause morality were more common among people with low levels of education in all types of country studied. However, variances in outcomes between educational levels were not explained by variances in risk factors, which decreased as educational level increased in high-income countries, but increased as educational level increased in low-income countries [61]. Furthermore, results from MONICA study suggested that lower education level among rural population could enhance CVD risk, but causality is difficult to prove [62].

In the present study, individuals living in urban areas were more prevalent in the consumption of unhealthy diet, sadness and stress. Recent global systematic evaluation of dietary consumption patterns across 195 countries found that improvement of diet prevents one in every five deaths globally and suboptimal diet was responsible for more deaths than other risk factors including smoking, highlighting the urgent need to improve people diet [63]. Urbanization is also associated with factors that could potentially influence the mental health and possibly the development of CVD, such as increased life stressors, overcrowding, higher level of violence, and less social support [64]. However, beside stress caused by transition from rural area to urban area, other cultural factors interplay with urban dynamics might contribute to the development psychological-related problems. Therefore, understanding how cultural dynamics interact with adaptation to urban life may help in appropriate management of mental disorders in cities [65]. Awareness of the negative impact of urbanization on mental health is needed across the Saudi society.

Healthcare is one of the main focus areas of the Saudi Vision 2030 where the Saudi government has initiated radical changes in the structure and function of its health-care system through its National Transformation Program (NTP) to achieve quality care and effective service delivery. In addition, the government has already recognized the importance of the primary prevention of CVD diseases and has announced recently four major projects, which aim to improve people lifestyle [66-71]. Furthermore, the World Heart Federation (WHF) has undertaken an initiative to develop a series of Roadmaps to reduce premature deaths from CVD by at least 25% by 2025. These Roadmaps can be used as guidance for countries toward developing or updating their national NCD programs for the prevention and control of NCD [72].

There are few limitations of our study. First, the sampling framework of the PURE-Saudi study was not nationally representative; hence caution is needed in generalizing our findings to the whole Saudi population. Additionally, it is possible that relatively healthier individuals were enrolled in our study; however; the similar high prevalence of CVD risk factors to the previous national surveys strengthens our study sampling methodology and results. Second, follow-up rates of CVD events and mortality were low, which is likely due to the small sample size. There are currently ongoing efforts to expand PURE Saudi to a larger population across all areas in the country in order to have meaningful event rates in the follow up. Lastly, we cannot exclude the role of genetic predisposition to such high prevalence of CVD risk factors, which could be related to the high consanguinity in the Saudi population. We have reported recently a high prevalence of familial hypercholesterolemia in Saudi Arabia and the rest of the Arabian Gulf countries [73].

Conclusion

The PURE-Saudi study demonstrated the continued high prevalence of unhealthy lifestyle and CVD risk factors in the adult Saudi population despite over a decade of several population surveys, and some of these factors were even more prevalent in the rural than the urban population. National awareness programs and multi-faceted health care policy changes are urgently needed to reduce the future burden of CVD risk and mortality.

Abbreviations

CVD: Cardiovascular diseases, PURE: Prospective Urban Rural Epidemiology, CHD: Coronary heart disease, GCC: Gulf Council Countries, IPAQ: International Physical Activity Questionnaire, MET: Metabolic equivalent of task, PHCC: Primary health care centers, SD: Standard deviations, IQR: Inter-quartile ranges, BMI: Body mass index, OHA: Oral hypoglycemic agents, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MI: Myocardial infraction, LDL: Low-density lipoprotein, TG: Triglyceride, HDL: High-density lipoprotein, CADISS: Coronary Artery Disease in the Saudis Study, NCD: Non-communicable diseases, WHO: World Health Organization, SHIS: Saudi Health Information Survey, MENA: Middle East and North Africa, HICs: High-income countries, LICs: Low-income countries, OPT: Occupied Palestinian Territory, UAE: United Arab Emirates, MONICA: Monitoring trends and determinants in cardiovascular disease, NTP: National Transformation Program, WHF: World Heart Federation.

Declarations

Ethics approval and consent to participate

King Saud University Ethics Committee granted ethical approval. Participation in the study was voluntary and all eligible subjects who provided written informed consent were enrolled.

Consent to publication

Not applicable.

Availability of data and materials

The data are not publicly available as the participants or the ethics committees have not given permission for sharing the data publicly and the study is ongoing.

Competing interests

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript. The authors declare that they have no competing interests.

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Authors Contributions

KFA and SY developed the study design. KFA, HA and MQA facilitated data gathering. KFA, MAB, THA and SR performed the data analysis and drafted the manuscript. All authors contributed to the interpretation of results and the revision of the manuscript as well as approved the final manuscript.

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Additional File Information

Additional Table 1. Risks of hyperlipidemia and hyperglycemia among men and women.

Additional Table 2. Risks of hyperlipidemia and hyperglycemia according to age.

Additional Table 3. Risks of hyperlipidemia and hyperglycemia in urban and rural population.

Additional Table 4. Characteristics of the PURE-Saudi study vs. past studies that have assessed the prevalence of cardiovascular disease risk factors in Saudi Arabia.

Figures

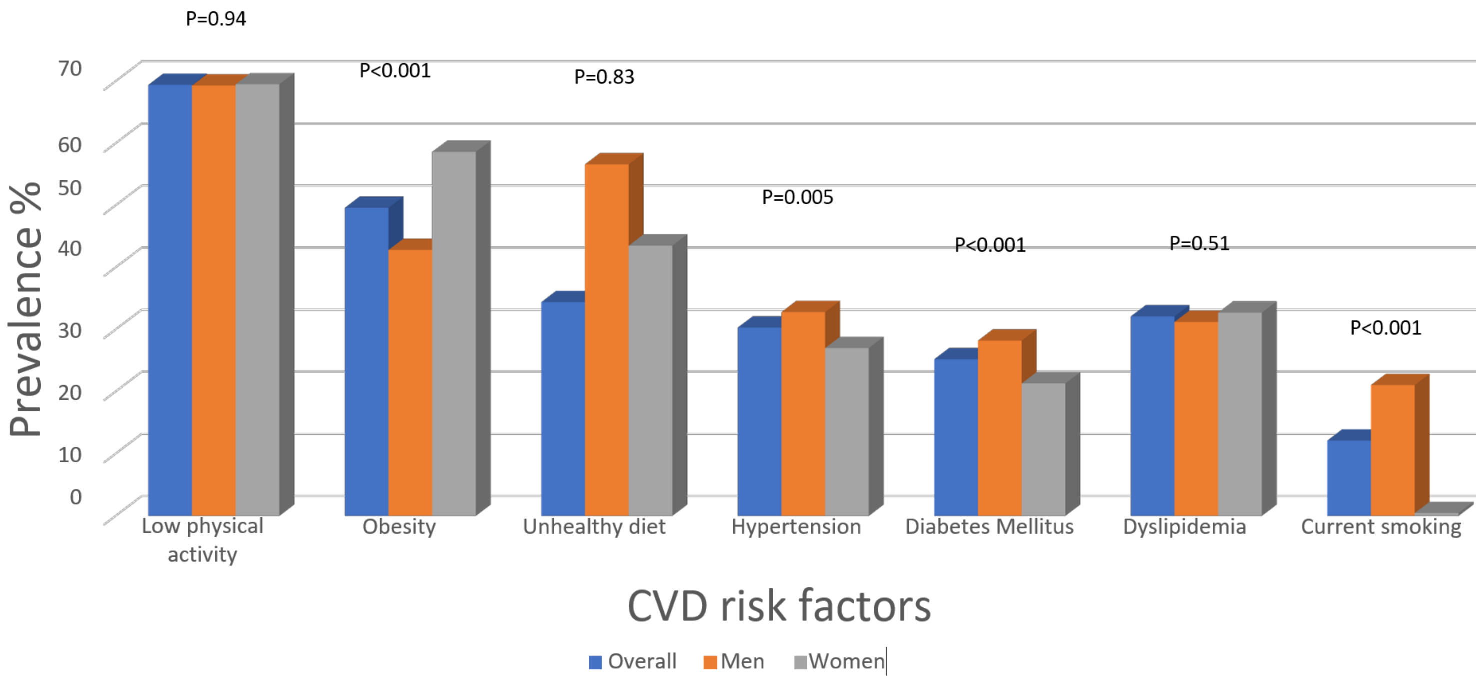

Figure 1

Prevalence of cardiovascular risk factors in the overall cohort and stratified by sex

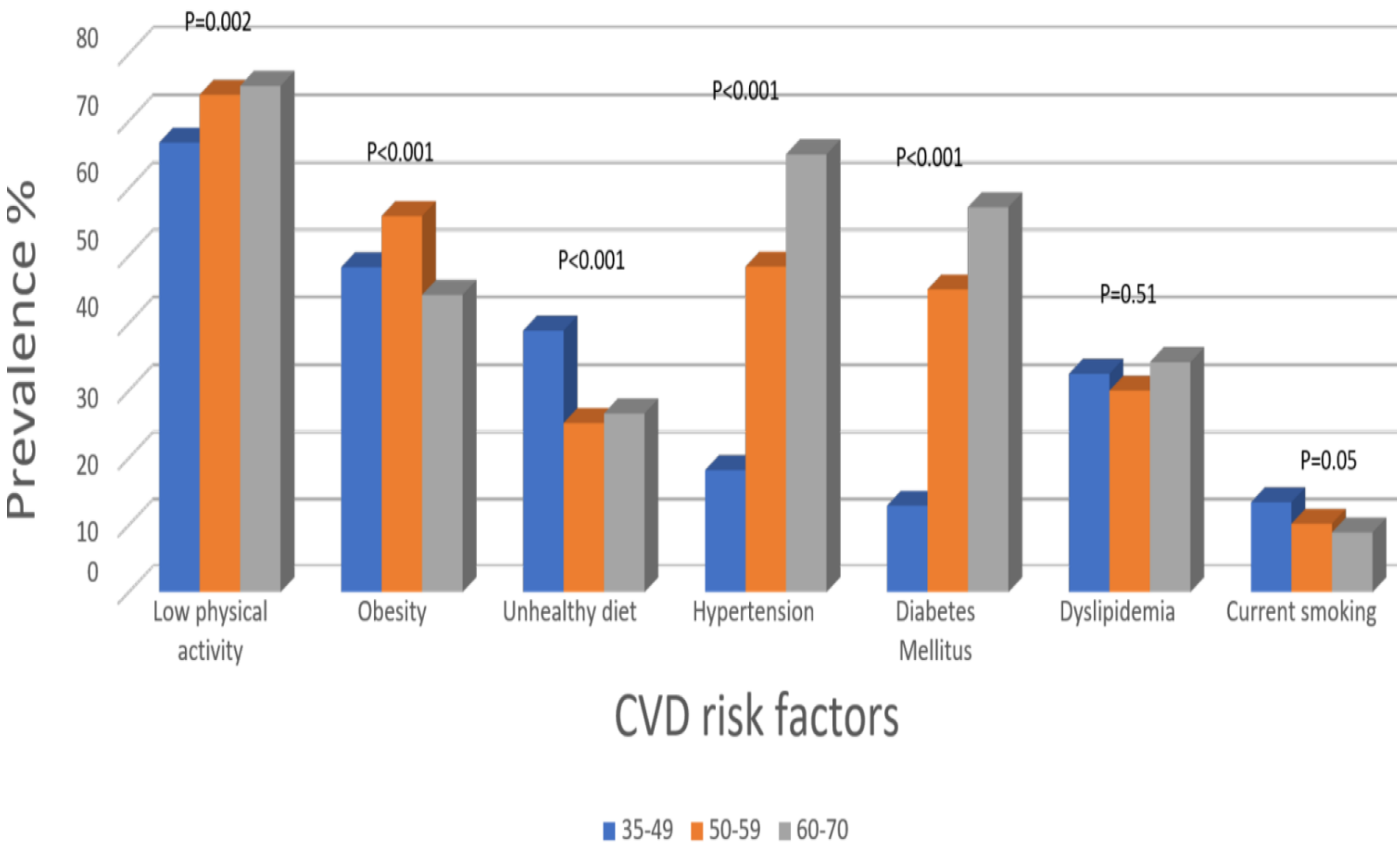

Figure 2

Cardiovascular risk factors stratified by age groups.

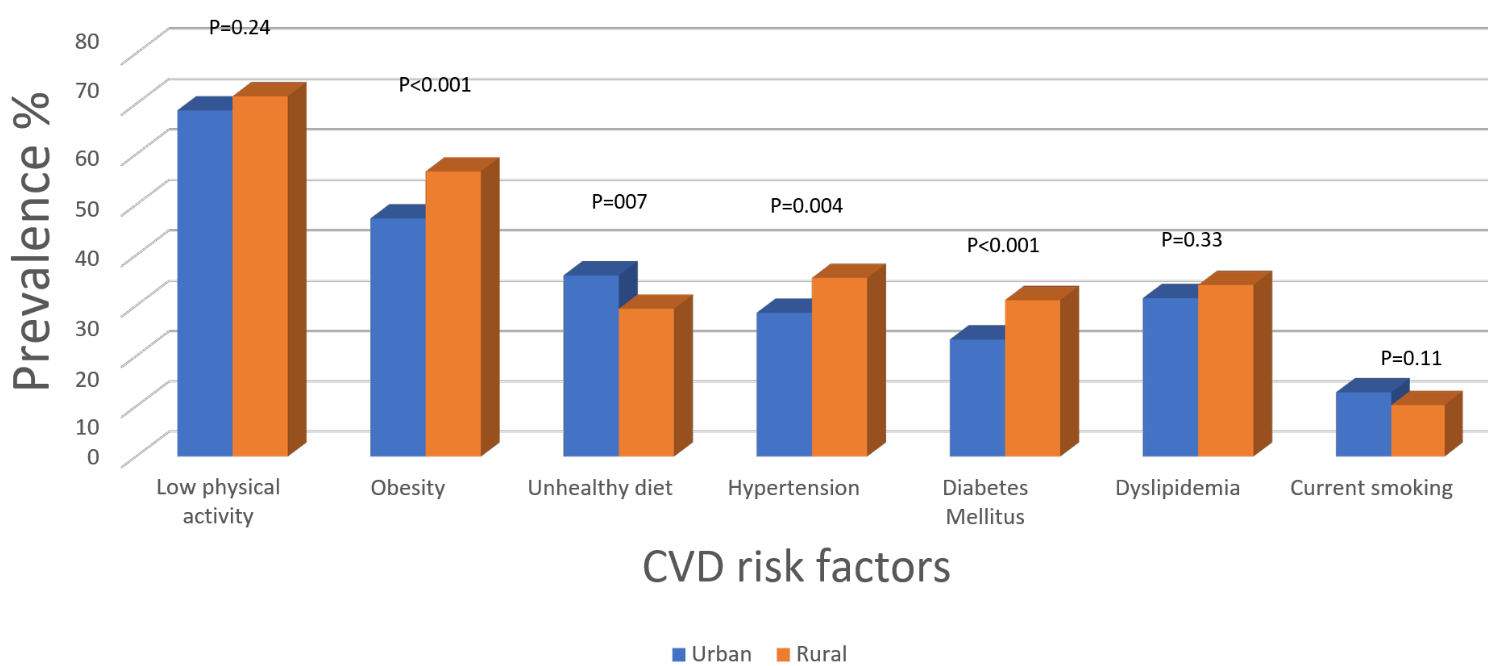

Figure 3

Cardiovascular risk factors stratified by residence place.

Supplementary Files

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

- additionaltable4.docx
- additionaltable1.docx
- additionaltable3.docx
- additionaltable2.docx