National trends in cardiovascular health metrics among Iranian adults using results of three cross-sectional STEPwise approaches to surveillance surveys

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To examine the trends of 7 cardiovascular health metrics (CVH metrics) incorporate of smoking, physical activity, diet, body mass index (BMI), fasting plasma glucose (FPG), total cholesterol (TC), and blood pressure (BP) level during three cross-sectional STEPwise approaches to surveillance (STEPS), 2007–2016, among Iranian adults. The study population consisted of 19,841 women and 17,243 men, aged 20–65 years. The CVH metrics were categorized as ‘ideal’, ‘intermediate’, and ‘poor’. The sex-stratified weighted prevalence rate of each CVH metrics was reported. The conditional probability of each poor versus combined intermediate and ideal metric was analyzed using logistic regression. In 2016 compared to 2007, the prevalence of poor BP level (20.4% vs. 23.7%), smoking (13.7% vs. 23.8%), TC ≥ 240 mg/dl (2.4% vs. 11.2%) and FPG < 100 mg/dl (75.6% vs. 82.3%) declined, whereas poor physical activity level (49.7% vs. 30%), poor healthy diet score (38.1% vs. 4.1%), BMI levels ≥ 25 kg/m² (62.8% vs. 57.8%) increased. Despite a high prevalence of obesity among women, it remained constant in women but showed an increasing trend in men; moreover, the trends of low physical activity and current smoking were better for women. Despite some improvement in CVH metrics, < 4% of Iranian adults meet ≥ 6 CVH metrics in 2016; this issue needs intervention at the public health level using a multi-component strategy.

Abbreviations

BP: Blood pressure
BMI: Body mass index
CVH metrics: Cardiovascular health metrics
CVD: Cardiovascular disease
CI: Confidence interval
FPG: Fasting plasma glucose
GPAQ: Global physical activity questionnaire
KNHANES: Korean National Health and Nutrition Examination Survey
METs: Metabolic equivalent tasks
NHANES: National Health and Nutrition Examination Survey
STEPS: STEPwise approaches to surveillance
TC: Total cholesterol
TLGS: Tehran Lipid and Glucose Study

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Cardiovascular Disease (CVD) persists as a critical public health problem despite the great global effort to reduce cardiovascular risk factors through primary prevention. Smoking, physical inactivity, high blood pressure, high cholesterol level, unhealthy diet alongside obesity, and glucose intolerance status contribute to persistent CVD. Achieving favorable changes in healthy lifestyle factors (even slightly) can have a considerable effect on decreasing the epidemiologic and economic health burden.

Based on evidence from randomized clinical trials, the American Heart Association (AHA) established the 2020 strategic impact goals, which incorporated 7 cardiovascular health metrics (CVH metrics), consisting of four health behaviors [body mass index (BMI), smoking status, physical activity, and diet] and three health factors [blood pressure (BP), fasting plasma glucose (FPG), and total serum cholesterol (TC)] for improvement of cardiovascular health. There is convincing evidence that a more ideal CVH metrics is accompanied by reduced risk of CVD and non-CVD outcomes such as cancer, depression, cognitive impairment, and diabetes.

Several cross-sectional studies have focused on the prevalence of CVH metrics in different populations. The distribution of ideal CVH metrics (characterized by achieving 6 or 7 ideal CVH metrics) between 2010 and 2015 was reported to be as low as 0.5–12% in the United States (US) and 0.3–10% in the non-US population. Among the seven CVH metrics, the highest and lowest prevalence for ideal CVH metrics was attributed to smoking status and diet, respectively. However, survey data showing the trends of CVH metrics among the general population are very limited. To the best of our knowledge, few population-based studies have been conducted among US, Canadian and Korean populations that examined the trends of all 7 ideal cardiovascular health metrics. Accordingly, two American National Health and Nutrition Examination Surveys (NHANES) between 1998 and 2010, the Korean National Health and Nutrition Examination Survey (KNHANES) between 2005 and 2009, and a Canadian study carried out from 2003 to 2011 showed no improvement in the prevalence of ideal CVH metrics.

STEPS surveys. Data was collected using a random multistage cluster sampling method in non-hospitalized and non-institutionalized Iranian adults, by trained interviewers during a household meeting. The STEPS survey was conducted in seven stages, between 2004 and 2016, four of which included laboratory measurements on a subsample population. In the current study, we used three STEPS, 2007, 2011, and 2016; which had similar methods for the measurement of all needed CVH metrics variables. Despite slight differences in sampling designs between the 3 surveys, and the smaller sample size in 2011 (due to financial constraints and economic programs), samples were representative of the Iranian adult population in all 3 surveys. Further details regarding STEPS have been previously published. We confirm that all research was performed following relevant guidelines, and confirming that informed verbal consent was obtained from all participants and/or their legal guardians. This study was approved by the Institutional Review Board (IRB) of the Research Institute for Endocrine Sciences (RIES), Shahid Beheshti University of Medical Sciences, Tehran, Iran, and all participants provided written informed consent.

Study population. For trends in CVH metrics, we used data from STEPS 2007 (n = 26,785), 2011 (n = 9967), and 2016 (n = 30,092). FPG and TC values were available for a subsample of adults aged 20–65 years [(2007 = 14,053), (2011 = 5384), (2016 = 19,450)]. After removing subjects with missing data on all 7 CVH metrics, 37,091 adults [(2007 = 13,699), (2011 = 5279), (2016 = 18,113)] remained for data analysis (Fig. 1).

Medical history, clinical examination, and laboratory measurements. Demographic information on sex, age, education, occupation as well as cigarette smoking, physical activity, and drug consumption were obtained from participants using a standard questionnaire based on the STEPS survey. Systolic and diastolic blood pressure (SBP and DBP) were recorded after at least 10 min of rest, three times within 5 min of each other, in a seated position from the right arm, using an appropriately-sized standard cuff sphygmomanometer (Omron M7 in 2007 and 2011, Beurer in 2016). The mean value was considered as the subject’s SBP and DBP. Height was measured with a portable, inflexible measuring bar in standing position with no shoes on, with a precision of 0.1 cm. Weight was measured using a digital scale in light clothing without shoes on and recorded to the nearest 0.1 kg. BMI was calculated as weight in kilograms divided by height in meters squared. For biochemical measurements, according to the standard protocol, 10–12 ml of the venous blood sample was drawn from each participant after at least 8 h of overnight fasting. Samples were sent to collaborating centers in 2007 and 2011, but in 2016 samples were sent to the Central Reference Laboratory of the Ministry of Health of Iran (Tehran, Iran) under cold chain conditions (4–8 °C). All samples were promptly centrifuged (1500 rpm for 10 min at standard room temperature: 21 °C). FPG was measured via enzymatic colorimetric method using glucose oxidize and TC level was checked via enzymatic photometric method using cholesterol esterase and cholesterol oxidase in
Definition of CVH metrics. We used AHA’s 2020 Impact Goals which defined three CVH metrics categories; ‘ideal’, ‘intermediate’, and ‘poor’(Table1). The subgroup of smoking status consists of current, former, and never-smokers, which were attributed ‘poor’, ‘intermediate’, and ‘ideal’ status, respectively. The AHA’s definition of ‘ideal’ smoking status includes never or quit smoking > 12 months, ‘intermediate’ groups include quit smoking less than 12 months ago, and ‘poor’ groups include smoking daily or occasionally. In the questionnaire, we categorized the ‘current’ smoker as a participant who smoked daily or occasionally, any amount of all kinds of tobacco (cigarette, pipe, hookah, etc.) at the time of the interview and ‘former’ as someone who had a history of smoking but had since quit. According to our questionnaire, we used average metabolic equivalent tasks score (METs) to define physical activity instead of using the duration of physical activity (used in AHA’s 2020 impact goals), which were calculated based on the global physical activity questionnaire (GPAQ). The GPAQ is a standardized questionnaire of physical activity developed by the WHO. ‘ideal’, ‘intermediate’, and ‘poor’ physical activity was defined as physical activity of ≥ 1500 MET mins/wk, 600–1500 MET mins/wk, and < 600 MET mins/wk, respectively. The corresponding metrics for BMI were ‘ideal’ (< 25.0 kg/m²), ‘intermediate’ (25.0–29.9 kg/m²) and ‘poor’ (≥ 30.0 kg/m²). AHA’s healthy diet score was defined by the sum of the following 5 components, allocating 1 point each for the consumption of fruits and vegetables (≥ 4.5 cups/d), fish (≥ two 3.5-oz servings/wk), fiber-rich whole grains (≥ three 1-oz equivalent servings/d), sodium(< 1500 mg/d), and sugar-sweetened beverages(< 36 oz./wk). Considering the limited data in our questionnaire, the modified healthy diet score was...

Figure 1. Flow chart of the study population in STEPS 2007–2016.
used based on only two components, daily fruits and vegetables, and fish servings in all 3 surveys. Participants were placed in the ‘ideal’ group if their fruit and vegetable consumption was ≥4 cups/d, and consumption of fish ≥ two 3.5-oz servings/wk. The ‘poor’ group comprised participants who consumed less than 2 cups/d fruits and vegetables, and without consumption of fish. All other participants were categorized as the ‘intermediate’ group. Statin therapy for high cholesterol level was recorded only for STEPS 2016, therefore we modified AHA’s definition of TC status, without considering treatment information in 2007 and 2011. We categorized participants as ‘ideal’ if TC < 200 mg/dl, ‘intermediate’ if TC level was 200–239 mg/dl, and ‘poor’ if they had a TC level equal or greater than 240 mg/dl. According to FPG level, participants were ranked as ‘ideal’ if untreated FPG was lower than 100 mg/dl, ‘intermediate’ if untreated FPG was 100–125 mg/dl or treated to lower than 125 mg/dl, and ‘poor’ if they had an FPG level equal or greater than 126 mg/dl. Subgroup classification of blood pressure level consisted of ‘ideal’ (SBP < 120 mmHg/DBP < 80 mmHg, untreated), ‘intermediate’ (120 mmHg ≤ SBP ≤ 139 mmHg/80 ≤ DBP ≤ 89 mmHg, or treated to ≤ 139/89 mmHg), and ‘poor’ (SBP ≥ 140 mmHg/DBP ≥ 90 mmHg).

To calculate the total CVH metrics score, in the first step we recoded each metric as a binary variable, assigning a score of 1 point to the ‘intermediate’ or ‘ideal’ category versus 0 points for the ‘poor’ category. A CVH metric total score was attained by summing up the newly defined variables. A total CVH metric score was categorized as ‘ideal’ if the total CVH metric score was 6–7, ‘intermediate’ if the score was 3–5, and ‘poor’ if the CVH metric score was less than 2.

**Statistical analysis.** In the current study, we used STEPS with a complex sampling design. To achieve a representative estimation of the Iranian population, a survey analysis was performed and weights were generated using categories of age, sex, area of residence (rural/urban), and 30 provinces, according to the national population of Iran (census, 2011). All data from 2007, 2011, and 2016 STEPs were pooled. The weighted prevalence rates (95% CI) of each health metric were estimated using Taylor-linearized variance estimation. The conditional probability of each poor vs. combined intermediate and ideal metric was analyzed by logistic regression, wherein the STEPs cycles were considered a continuous independent variable, and linear trends in the probability of each health metric were examined. Differences across the sexes were examined by using interaction terms (e.g., sex × STEPs cycle). All analyses were performed using STATA 14, and p value < 0.05 was considered statistically significant.

**Results**

Demographic characteristics of the study participants are described in Table 2. The mean CVH metrics score increased slightly during 2007–2016 (4.7 in 2007 [95% CI 4.7–4.8]; 4.9 in 2011 [95% CI 4.8–5.0]; 5.0 in 2016 [95% CI 4.9–5.0]).

As shown in Table 3, in 2016 compared to 2007, the prevalence of current smoking (13.7% vs. 23.8%), poor TC (2.4% vs. 11.2%), and poor BP level (20.4% vs. 23.7%) declined, whereas poor physical activity level (49.7% vs. 30.0%), poor healthy diet score (38.1% vs. 4.1%) as well as poor and intermediate BMI levels (23.7% vs. 21.6% and 39.1% vs. 36.2%, respectively) were significantly increased. Regarding poor FPG level, we did not find a consistent change in prevalence during these years, considering significant overlap features in their confidence intervals, but the prevalence of ideal glucose level (FPG <100 mg/dl) decreased [82.3% in 2007 (95% CI 81.5–83.1%) to 75.6% in 2016 (95% CI 74.8–76.3%)]. The prevalence of all 7 ideal CVH metrics was less than 0.5% during this period. The prevalence of meeting 6 CVH metrics was 5.5% in 2007, 6.7% in 2011, and 3.4% in 2016. Among different CVH metrics, those with 3 and 4 indices had the highest prevalence in each of the three STEPS surveys, and the prevalence of CVH metrics in these groups did not change significantly during 2007–2016.

Tables 4 and 5 show the prevalence and trend of each CVH metrics in women and men, separately. We found that in each cycle, the prevalence of low physical activity and obesity but not overweight status were significantly higher in women than in men, while current smoking was more prevalent in men. The trends of all 7 CVH metrics during this period were generally similar to the trends among the total population (see above), except for overweight/obesity status, which remained constant in women and increased in men.

| CVH metrics | Ideal | Intermediate | Poor |
|-------------|-------|--------------|------|
| Current smoking | Never | Former | Poor |
| Physical activity level | ≥ 1500 METs/week | 600–1500 METs/week | < 600 METs/week |
| BMI, kg/m² | < 25.0 | 25.0–29.9 | > 30.0 |
| Healthy diet score | F&V (≥ 4 cups/week) and fish (≥ two 3.5-oz servings/week) | Not included in ideal or poor group | F&V (< 2 cups/week), no fish consumption |
| TC, mg/dl | < 200 | 200–239 | ≥ 240 |
| FPG, mg/dl | < 100, untreated | 100–125 or treated | ≥ 126 |
| SBP/DBP, mmHg | < 120/80, untreated | 120–139/80–89, or treated | ≥ 140/90 |

Table 1. The modified American Heart Association 2020 impact goals of ideal, intermediate, and poor CVH metrics. CVH metrics, cardiovascular health index; METs, metabolic equivalent tasks; BMI, body mass index; F&V, fruit and vegetable; TC, total cholesterol; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure. *F&V (≥ 4 cups/d) without fish, F&V(2–4 cups/d) and fish (≥ one 3.5-oz serving/week), F&V (< 2 cups/d) and fish ((≥ one 3.5-oz serving/week), fish (≥ one 3.5-oz serving/week) without F&V.
|                    | 2007            | 2011            | 2016            |
|--------------------|-----------------|-----------------|-----------------|
| Male               | Female          | Total           | Male            | Female          | Total           | Male            | Female          | Total           |
| No                 | 6971            | 6728            | 13,699          | 1970            | 3302            | 5272            | 8302            | 9811            | 18,113          |
| Mean age (year)    | 41.3 (41.1–41.6)| 41.0 (40.8–41.3)| 41.2 (41.0–41.3)| 40.7 (40.3–41.2)| 40.8 (40.2–41.4)| 40.8 (40.4–41.3)| 41.7 (41.5–41.9)| 42.0 (41.8–42.3)| 41.8 (41.7–42.0)|
| Urban% (95% CI)    | 67.9 (66.8–68.9)| 69.6 (68.6–70.6)| 68.6 (67.9–69.3)| 78.7 (76.7–80.6)| 74.0 (72.5–75.5)| 76.0 (74.8–77.2)| 77.1 (76.5–77.7)| 75.8 (75.2–76.3)| 76.4 (76.0–76.9)|
| Antihypertensive medicine% (95% CI) | 4.0 (3.5–4.6)       | 7.5 (6.9–8.1)       | 5.5 (5.1–6.0)       | 4.8 (3.9–5.8)       | 8.4 (7.5–9.5)       | 6.9 (6.2–7.7)       | 12.1 (11.3–13.0) | 15.6 (14.8–16.3) | 13.9 (13.3–14.4) |
| Antihyperglycemic medicine% (95% CI) | 2.9 (2.4–3.4)          | 4.6 (4.1–5.2)          | 3.6 (3.3–4.0)          | 4.0 (3.2–5.0)          | 5.7 (4.9–6.7)          | 5.0 (4.4–5.7)          | 3.5 (3.1–4.0)          | 4.9 (4.4–5.3)          | 4.1 (3.9–4.5)          |
| Stain treatment% (95% CI) | N/A             | N/A             | N/A             | N/A             | N/A             | N/A             | 5.0 (4.5–5.4) | 6.3 (5.9–6.7) | 5.6 (5.3–5.9) |

Table 2. Demographic characteristics of the Iranian adult population in STEPS 2007–2016. STEPS, STEPwise approach to surveillance.

Discussion

In the current study, we examined the trends of poor, intermediate, and ideal levels of CVH metrics during 3 consecutive national surveys from 2007 to 2016. Throughout these surveys, the prevalence of BP level ≥ 140/90 mmHg, TC ≥ 240 mg/dl, and current smoking status decreased in both genders. However, overweight and obesity status increased among men, and physical activity of less than 600 MET mins/wk and modified poor diet score increased in both genders. Moreover, the prevalence of prediabetes (but not diabetes state) increased significantly in both genders. Unfortunately, only about 6% and 3.8% of the total population met 6 or more ideal CVH metrics in 2007 and 2016, respectively.

The low prevalence of ideal CVH metrics is a global health problem, notably in low- and middle-income countries. To the best of our knowledge, 4 studies conducted in developing countries (India, Iran, Bosnia/Herzegovina, and Ecuador), exhibited a low prevalence of ≥ 6 ideal CVH metrics (0.3–4%). Similarly, in the current study, although this prevalence reached about 7.2% in 2011, it again decreased to < 4% in 2016. The consistently low trends of ideal CVH metrics were also confirmed in national studies conducted in the US (i.e. < 10%)<sup>1</sup>, Canada (< 8.9%)<sup>2</sup>, and Korea (< 14%)<sup>2</sup>. Moreover, the intermediate categories of CVH metrics (i.e. having 3, 4, and 5 ideal CVH metrics) had the highest prevalence in both genders in this study (~ 70%). Comparable values in NHANES and KNHANES were 64.4–66.3% and 66.7–71%, respectively<sup>4,6</sup>.

The trend of current smoking status was shown to decline from 23.8 to 13.7%. The trend analysis of previous studies in the US and non-US population also reflect the improvement of smoking status. This reduction rate was more pronounced among women, a finding similar to that observed in the KNHANES and Canadian study<sup>4,6</sup>. Moreover, it is important to note that Iranian women are more likely to underreport smoking behaviors, given the social shame of smoking<sup>17</sup>. Unfortunately, in 2016, about 1 out of 4 Iranian men were current smokers. Importantly, more than 19% of the population attributable fraction (PAF) of premature CVD among men was attributed to current smoking<sup>18</sup>. This risk might be minimized by effective programs such as raising taxes on cigarettes as well as the development of a workplace smoking regulation and smoking restriction at the national level.

The favorable trend of poor total cholesterol level in our study (11.2% in 2007 to 2.4% in 2016) was significantly better than a comparable change in the US (20.6% in 1988–1994 to 14.2% in 2005–2010)<sup>3</sup> and Korea (5.4% in 2005 to 7.6% in 2009)<sup>2</sup>. The decreasing trend in lipid levels in our data registry could hardly be explained by lifestyle changes (i.e. increasing physical activity) since it was shown that low physical activity increased from 30.0 to 49.7% during this period, or by the use of lipid-lowering medications (only 5.6% in 2016). Despite this, due to extensive media advertising against the consumption of saturated fatty acids, it was shown that over 30% of Iranian families now consume less hydrogenated oil than they used to in the past<sup>19</sup>, which could explain the favorable lipid trend in the Iranian population during our surveys.

Poor diet scores stemming from low consumption of fruits, vegetables, and fish demonstrated a significant increase from 4.1% in 2007 to 38.1% in 2016 in our study. The average daily consumption of fruits and vegetables among the Iranian adult population in 2007 (2.58 servings per day) was reported to be lower than the average value recommended by WHO (5 or more servings per day)<sup>20</sup>. Our results were in line with nutritional status worldwide, with a healthy diet score being reported to be the poorest CVH metrics in the previous US and non-US studies<sup>4,6</sup>. According to Global Burden of Disease results, the consumption of whole-grain in the MENA region was about one-third of the global average; hence, this downward shift in nutritional status would be more
pronounced if this item had been included in our study. From 2007 to 2016, rising living costs and rising inflation that might be attributable to the country’s long years of sanctions reduced people’s access to healthy diets that contain enough vegetables and fruits. This issue, along with the numerous preoccupations of people to earn enough income, has led to not allocating enough time to prepare healthy diets, in other words, the food pattern has increasingly changed to a Western diet incorporating caloric dense and sucrose-enriched drinks. Also, the occurrence of natural disasters such as floods, earthquakes, and droughts frequently during these years along with political instability in the region, especially in neighboring countries, has become an important reason for the growing decline in healthy nutrition in the people.

Recent reports have shown that the mean physical activity level in the MENA region was approximately 1000 MET mins/wk less than the average global value for both genders. This low physical activity level might be explained by rapid urbanization, industrialization, and a sedentary lifestyle due to occupational and transport

| Smoking status | 2007 | 2011 | 2016 |
|----------------|------|------|------|
| Never          | 9822 | 4417 | 14,197 |
| Former         | 1072 | 209  | 1436  |
| Current        | 2805 | 646  | 2480  |

| Physical activity | 2007 | 2011 | 2016 |
|-------------------|------|------|------|
| Ideal             | 7497 | 2138 | 6710 |
| Intermediate      | 2114 | 854  | 2496 |
| Poor              | 4088 | 2280 | 8907 |

| BMI (kg/m²) | 2007 | 2011 | 2016 |
|-------------|------|------|------|
| < 25.0      | 5644 | 2001 | 6609 |
| 25.0–29.9   | 4989 | 1928 | 6942 |
| ≥ 30.0      | 3066 | 1343 | 4562 |

| Healthy diet score | 2007 | 2011 | 2016 |
|--------------------|------|------|------|
| Ideal              | 438  | 206  | 335  |
| Intermediate       | 12,644 | 3875 | 10,507 |
| Poor               | 617  | 1191 | 7271 |

| TC (mg/dL) | 2007 | 2011 | 2016 |
|------------|------|------|------|
| < 200      | 8298 | 3493 | 15,317 |
| 200–239    | 3574 | 1260 | 2273 |
| ≥ 240      | 1827 | 519  | 523  |

| FPG (mg/dL) | 2007 | 2011 | 2016 |
|-------------|------|------|------|
| < 100 (untreated) | 10,912 | 3682 | 13,014 |
| 100–125 (treated) | 1818 | 1041 | 3654 |
| ≥ 126       | 969  | 549  | 1445 |

| SBP/DBP (mmHg) | 2007 | 2011 | 2016 |
|---------------|------|------|------|
| < 120/80 (untreated) | 4064 | 1512 | 5784 |
| 120–159/80–89 (treated) | 5568 | 2138 | 7486 |
| ≥ 140/90      | 4067 | 1622 | 4843 |

| No. of ideal CVH metrics | 2007 | 2011 | 2016 |
|--------------------------|------|------|------|
| 0                        | 15   | 6    | 12   |
| 1                        | 595  | 213  | 712  |
| 2                        | 2216 | 853  | 2917 |
| 3                        | 3674 | 1267 | 4893 |
| 4                        | 3818 | 1447 | 5360 |
| 5                        | 2461 | 998  | 3240 |
| 6                        | 848  | 459  | 893  |
| 7                        | 72   | 29   | 86   |

| Mean CVH metrics (95% CI) | 2007 | 2011 | 2016 |
|---------------------------|------|------|------|
| 4.7 (4.7–4.8)             | 4.9  (4.8–5.0) | 5.0 (4.9–5.1) |

Table 3. Prevalence of cardiovascular health metrics in adults in STEPS 2007, 2011, 2016. Data from each survey is weighted for age, sex, area of residence, on the basis of the Iranian census population 2011. STEPS, STEPwise approach to surveillance; CI, confidence interval; BMI, body mass index; TC, total cholesterol; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; CVH metrics, cardiovascular health index. SI conversion factors: to convert total cholesterol values to mmol/L, multiply by 0.0259; to convert glucose values to mmol/L, multiply by 0.0555.
facility changes in the region\textsuperscript{21}. On the other hand, in contrast to the results of NHANES and KNHANES, the trend of low physical activity increased from 2007 to 2016, with a significantly higher slope in men, although women had significantly higher values of physical inactivity across all three surveys. The higher prevalence of physical inactivity among women may be linked to their role as caregiver to another family member in the house, their lower-income, and cultural issues that limit the participation of women in some sports\textsuperscript{23}. To promote physical activity, public health agencies should reinforce appropriate public health education and organize strategic intervention programs among adults in Iran, such as the development of public sports facilities.

Regarding pre-hypertension and hypertension status, the favorable trend observed in 2005–2011\textsuperscript{19}, continued until 2016. Despite this, in 2016, 3 out of 5 adults had pre-hypertension/hypertension. Accordingly, among the participants of the Tehran Lipid and Glucose Study (TLGS), the highest PAF for CVD among potential risk factors was attributed to hypertension, reaching 21.6\%\textsuperscript{24}. Unfortunately, the prevalence of pre-hypertension remained

Table 4. Prevalence of cardiovascular health metrics among females in STEPS 2007, 2011, 2016. Data from each survey is weighted for age, sex, area of residence, on the basis of the Iranian census population 2011. STEPS, STEPwise approach to surveillance; CI, confidence interval; BMI, body mass index; TC, total cholesterol; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; ICVH, Ideal cardiovascular health metrics. SI conversion factors: To convert total cholesterol values to mmol/L, multiply by 0.0259; to convert glucose values to mmol/L, multiply by 0.0555.
constant at about 43% during this period. Importantly, the presence of prehypertension was shown to be significantly associated with CVD and mortality. The slight favorable trend of hypertension in contrast to low physical activity, poor diet status, and high salt intake might be justified by other contributing factors such as the increase in the use of antihypertensive drugs. The high prevalence of intermediate and poor BP levels among Iranian residents requires immediate preventive programs, consisting of encouraging physical activity, reducing salt intake, as well as increasing the consumption of fruits, vegetables, and a potassium-rich diet.

| Table 5. Prevalence of cardiovascular health metrics in among males in STEPS 2007, 2011, 2016. Data from each survey is weighted for age, sex, area of residence, on the basis of Iranian census population 2011. STEPS, STEPwise approach to surveillance; BMI, body mass index; TC, total cholesterol; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; ICVH, Ideal cardiovascular health metrics. SI conversion factors: to convert total cholesterol values to mmol/L, multiply by 0.0259; to convert glucose values to mmol/L, multiply by 0.0555. |
|----------------------------------------|------------------|------------------|------------------|------------------|
| Smoking status                        | No | Prevalence (95% CI) | No | Prevalence (95% CI) | No | Prevalence (95% CI) |
| Never                                 | 3609 | 48.8 (47.3–40.3) | 1280 | 65.1 (62.2–68.0) | 5110 | 64.5 (63.2–65.8) |
| Former                                | 1000 | 14.2 (13.0–15.3) | 185 | 7.7 (6.2–9.3) | 1113 | 11.0 (10.2–11.8) |
| Current                               | 2362 | 37.0 (35.6–38.5) | 505 | 27.1 (24.4–29.8) | 2079 | 24.5 (23.3–25.7) |
| Physical activity                     |     |                 |     |                 |     |                 |
| Ideal                                 | 4628 | 64.9 (63.4–66.4) | 1108 | 57.2 (54.2–60.2) | 4091 | 48.1 (46.7–49.5) |
| Intermediate                          | 821 | 12.5 (11.4–13.6) | 265 | 14.2 (12.0–16.4) | 1045 | 12.8 (11.9–13.7) |
| Poor                                  | 1522 | 22.6 (21.2–23.9) | 597 | 28.6 (25.9–31.3) | 3166 | 39.1 (37.7–40.4) |
| BMI (kg/m²)                           |     |                 |     |                 |     |                 |
| < 25.0                                 | 3524 | 50.4 (48.0–51.6) | 899 | 45.2 (42.7–48.2) | 3549 | 41.8 (40.5–43.2) |
| 25.0–29.9                             | 2490 | 35.8 (34.3–37.3) | 752 | 38.5 (35.5–41.5) | 3359 | 41.1 (39.7–42.4) |
| ≥ 30                                   | 957 | 14.2 (13.0–15.3) | 319 | 16.2 (14.0–18.4) | 1394 | 17.1 (16.0–18.1) |
| Health diet score                     |     |                 |     |                 |     |                 |
| Ideal                                 | 214 | 3.2 (2.7–3.8) | 214 | 4.3 (3.0–5.5) | 147 | 1.9 (1.5–2.2) |
| Intermediate                          | 6445 | 92.5 (91.7–93.2) | 6445 | 73.0 (70.4–75.7) | 4840 | 59.9 (58.5–61.2) |
| Poor                                  | 312 | 4.3 (3.7–4.9) | 312 | 22.7 (20.2–25.2) | 3315 | 38.2 (36.9–39.6) |
| Cholesterol (mg/dL)                   |     |                 |     |                 |     |                 |
| < 200                                  | 4543 | 67.3 (65.9–68.8) | 1411 | 73.4 (70.8–76.1) | 7198 | 87.0 (86.0–87.9) |
| 200–239                                | 1686 | 23.0 (21.8–24.3) | 436 | 21.2 (18.8–23.7) | 932 | 10.9 (10.0–11.7) |
| ≥ 240                                  | 742 | 9.6 (8.7–10.5) | 123 | 5.3 (4.0–6.0) | 172 | 2.2 (1.7–2.6) |
| FPG (mg/dL)                            |     |                 |     |                 |     |                 |
| < 100 (untreated)                     | 5616 | 82.5 (81.4–83.6) | 1382 | 75.0 (72.4–77.4) | 5978 | 74.7 (73.6–76.0) |
| 100–125 or treated                    | 919 | 11.9 (10.9–12.9) | 396 | 18.1 (15.8–20.4) | 1213 | 19.7 (18.6–20.7) |
| ≥ 126                                 | 436 | 5.6 (4.9–6.3) | 192 | 6.9 (5.6–8.2) | 601 | 5.6 (5.1–6.2) |
| SBP/DBP (mmHg)                        |     |                 |     |                 |     |                 |
| < 120/80 (untreated)                  | 1943 | 30.4 (28.9–31.8) | 486 | 28.8 (26.0–31.6) | 2377 | 31.3 (30.3–32.6) |
| 120–139/80–89 or treated              | 3049 | 46.6 (45.0–48.1) | 885 | 48.6 (45.6–51.7) | 3771 | 48.3 (47.0–49.7) |
| ≥ 140/90                              | 1979 | 23.1 (21.8–24.3) | 599 | 22.6 (21.2–24.9) | 2154 | 20.3 (19.2–21.3) |
| No. of CVH metrics                    |     |                 |     |                 |     |                 |
| 0                                     | 8 | 0.1 (0.0–0.2) | 2 | 0.1 (–0.05–0.3) | 7 | 0.1 (0.0–0.17) |
| 1                                     | 311 | 4.0 (3.1–4.8) | 77 | 5.0 (3.7–6.3) | 369 | 4.8 (4.2–5.3) |
| 2                                     | 1217 | 15.7 (14.2–17.2) | 349 | 21.0 (18.6–23.4) | 1351 | 17.6 (16.6–18.6) |
| 3                                     | 1927 | 27.0 (25.0–29.0) | 499 | 25.9 (23.3–28.4) | 2242 | 28.3 (27.2–29.5) |
| 4                                     | 1889 | 27.0 (25.0–29.0) | 524 | 25.5 (23.1–28.0) | 2359 | 27.9 (26.7–29.1) |
| 5                                     | 1135 | 18.3 (16.6–20.0) | 349 | 16.2 (14.2–18.3) | 1474 | 16.1 (15.2–17.1) |
| 6                                     | 425 | 7.1 (6.0–8.3) | 152 | 5.5 (4.4–6.6) | 439 | 4.4 (3.9–4.9) |
| 7                                     | 59 | 0.8 (0.5–1.2) | 18 | 0.7 (0.2–1.3) | 61 | 0.6 (0.4–0.8) |
| Mean CVH metrics (95% CI)             | 4.7 (4.6–4.8) | 4.8 (4.7–4.9) | 5.0 (4.9–5.1) |
advocacy, this will be expected to increase by 51%, reaching 700 million in 2045; most of this increase is expected to arise from the MENA region29. The significant increase in abnormalities in glucose metabolism could be related to an aging population, unhealthy lifestyle, and physical inactivity due to a growing urban population. In our study, the prevalence of obesity in each survey was higher among women than in men, similar to other countries in the MENA region30. The high prevalence of obesity among Iranian women might be attributable to the high prevalence of low physical activity as discussed above; moreover, the high parity rate among women was addressed as an underlying factor of obesity in this gender31. Among Iranians, the PAF of BMI ≥ 25 kg/m² for type 2 diabetes among women and men was 34.6% and 27.1%, respectively28. The TLGS demonstrated that among modifiable risk factors, the PAF of diabetes for CVD and all-cause mortality were about 14% and 24%, respectively, while the PAF of CVD attributed to being overweight or obese was about 24%34. Hence, the

Figure 2. Conditional probability and trend of seven poor health metrics compared to ideal and intermediate categories as a reference among men and women. **0.0001 < p value ≤ 0.001; *0.001 < p value ≤ 0.05. TC, total cholesterol; BMI, body mass index; FPG, fasting plasma glucose; HTN, hypertension; CVH, cardiovascular health.
significant increase in the prevalence of being overweight/obese and impaired glucose intolerance could negate the favorable trend of hypercholesterolemia, smoking, and hypertension. To address these paradoxical trends, implementing public health interventions that target lifestyle change by educating people regarding the advantages of a healthy diet and increasing physical activity is seriously advised; the impact of which was shown for up to 6 years in reducing metabolic syndrome among Tehranian residents.

Implementing multicomponent community-based prevention strategies in the form of NGOs and charitable organizations, health marketing strategies to raise public awareness about health behaviors, using community health workers (Behvarz) especially in deprived rural areas, applying smartphone preventive program to improve the quality of health care, adopting general practitioners and other health workers to assign community members to a link worker, and finally preventive, diagnostic, and therapeutic services may improve cardiovascular health status. Major gains will likely achieve from public health strategies targeting incorrect diet, physical inactivity, and preventing or stopping cigarette smoking. As a successful example, in a community-based study in Tehran, it was shown that family–school and community based educational sessions resulted in about 20% decrease incidence of metabolic syndrome during 6 years follow up.

**Strengths and limitations.** To the best of our knowledge, this is one of the few studies examining the trends of CVH metrics (alongside the US, Canadian, and Korean studies). Moreover, the fact that this study measured 7 CVH metrics over 10 years and examined trends in each gender is another strong point. However, our study had some limitations. First, we used a subsample of the STEPS population; namely those with complete data on CVH metrics, which might diminish the exact assessment of CVH metrics trends in the Iranian population. Second, the sampling method performed in 2016 differed slightly from 2007 and 2011; however, all samples taken in the three surveys were representative of the Iranian population. Third, self-reporting of physical activity, cigarette smoking, and dietary records in our surveys could cause recall bias and imprecise estimation of cardiovascular health status. Fourth, only 2 components of a healthy diet were used for assessment of nutritional status. Our modified diet score may not reflect the complete effect of diet on cardiovascular health status.

**Conclusion**

The prevalence of ideal CVH metrics remained very low during 2007–2016 and in the last survey, less than 4% of Iranian adults met the criteria of 6 or more ideal CVH metrics. Although the levels of smoking, TC, and BP had improved slightly, the unfavorable trends of physical activity, unhealthy diet, obesity, and ideal FPG need immediate attention at a public health level using a multi-component strategy.

**Data availability**

Data are available from the corresponding author on reasonable request.

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The authors declare no competing interests.

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