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# Validity of self-reported hypertension and related factors in the adult population: Preliminary results from the cohort in the west of Iran

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## Abstract

This study aimed to investigate the validity of self-reported hypertension and related factors in the Dehgolan Prospective Cohort Study (DehPCS). Data were obtained from 3996 participants aged 35–70 years in the enrolment phase of DehPCS. Self-reported hypertension and sociodemographic factors were collected by well-trained interviewers before hypertension diagnosis based on the reference criteria. The history of anti-hypertensive medication use and/or systolic blood pressure ≥140 (mmHg), or diastolic blood pressure ≥90 (mmHg) were considered as hypertension. Disagreement between self-reported and reference measures was assessed using sensitivity, specificity, positive, and negative predictive values (PPV and NPV), and kappa values. Binary and multinomial logistic regressions were used to investigate the correlates of validity of self-reported hypertension. The hypertension prevalence based on self-reports and the reference criteria was 19.49% and 21.60%, respectively. An acceptable percentage of kappa agreement value of 68.7% and relatively good overall agreement of 89.8% were found. Self-reported hypertension was guaranteed moderate sensitivity of 72.0% and high specificity of 94.5%, as well as the NPV and PPV of 92/7% and 77/9%, respectively. The chances of false-positive and false-negative reporting increased with older age, higher BMI, and a family history of hypertension. Being female, older age, higher BMI, concurrent diabetes, and stronger family ties to hypertension patients significantly increased the chance of reporting true positives relative to true negatives. Although, self-reported hypertension has an acceptable validity and can be used as a valid tool for screening epidemiological studies, it needs to be investigated because its validity is affected by age, gender, family history of hypertension, and other socio-demographic characteristics.

KEYWORDS
hypertension, self-reporting, sensitivity, specificity, validity

## 1 | INTRODUCTION

Hypertension is a major risk factor for almost all cardiovascular diseases (CVD) including heart diseases, stroke, and renal failure.[1] In terms of DALY, hypertension was the sixth leading risk factor among both males and females in 1990 and had arisen as the second and first leading risk factor among males and females by 2019. hypertension, with 5 250 000 attributed deaths, it was the leading risk factor for death among men and women in 2019.[2]

Monitoring the risks of cardiovascular diseases and planning for prevention and public health interventions require high-quality prevalence estimates based on medical measurements. The high cost and long-term collection of objective medical measurements have led some researchers to rely on self-reported hypertension to estimate the prevalence and burden of the disease.[3] In the absence of objective and widespread prevalence measurements, self-reported diagnoses may include a comprehensive information source for recording clinical and subclinical conditions.[4] Estimating hypertension through a self-report approach in population-based surveys has benefits including low cost and rapid implementation.[5] However, like any other diagnostic tests, classification bias is expected to occur with unavoidable false positives and negatives.[5,6]

Present studies have shown differences between self-reported and measured estimates of health-related data.[7] Evidence from developed countries shows there is a large difference between self-reported and clinical measurements of hypertension and diabetes, and this disagreement may vary among different socioeconomic groups.[3] For example, gender, age, education, questioning style, and interview type (in-person or by telephone) may influence individuals' responses to the questions about their disease status.[8] The accuracy of self-reported data on medical records may also be affected by the patient's knowledge, ability to recall and willingness to report, and whether the disease has already been diagnosed.[9] Therefore, the rate of inaccurate self-reporting may considerably vary, depending on the disease and population.

Although developed countries have shown significant differences between self-reporting and objective diagnosis of hypertension, the performance of developing countries due to limited data is unclear.[3] Several studies have shown there is little correlation between self-reports and clinical data although few have examined the reasons for such differences. In other words, information about respondents whose self-reported data differed from the objective diagnosis of hypertension was limited. Identifying and analyzing the social, demographic, medical, and economic characteristics of these individuals provides a clear view of their characteristics to policymakers. Evaluating such inconsistencies is crucial for estimating accurate information and minimizing measurement errors. Therefore, the present study aimed to investigate the validity of self-reported hypertension and its sociodemographic factors. To achieve this goal, we used the preliminary results of the Dehgolan prospective cohort study (DehPCS) on Kurdish people.

## 2 | METHODS

### 2.1 | Study population

The present study was performed using the information of men and women aged 35–70 years, who participated in the enrollment phase of the DehPCS which was part of the prospective epidemiological cohort studies in Iran (PERSIAN). The PERSIAN cohort included 18 studies aimed at assessing the incidence, prevalence, mortality, and risk factors of common noncommunicable diseases in Iran. Participants in the study included permanent residents of Dehgolan City with a minimum residence period of 1 year, the ability to communicate, and Iranian citizenship. The exclusion criteria were physical and mental communication disabilities and unwillingness to participate in the study.

After inviting the eligible people and explaining the study objectives, the participants signed the consent forms to participate in the study. Out of 4400 participants, 3996 were evaluated at the baseline (91% response rate). Details of the study design and DehPCS profile were presented in another study.[10]

### 2.2 | Measurements and data collection

The questionnaires used in this study included 482 items in three sections of general factors (demographic and socioeconomic characteristics, lifestyles, environmental exposure, occupational exposure, physical activities, and personal habits), medical factors (medical history, clinical symptoms, family health history, drug use, reproductive history, oral health, general health, anthropometry, physical exams, blood, and urine analysis), and nutritional factors (food frequency, eating habits, and supplementation). All data were collected by trained teams using online software specific to this study in the form of face-to-face interviews and physical examinations.

From each participant, a sample of fasting blood (25 ml), urine (at least 10 ml), hair (1–3 cm from the base of the head), and nails (from ten fingernails or toenails) were collected and tagged by trained technicians. Weight and height were measured using the Seka scale and seka stadiometer, respectively, with an accuracy of .1 cm. The body mass index (BMI) was calculated as weight (kg) divided by the square of height ($m^2$).

The basis for calculating the participants' age was their official identity cards, and education was assessed based on the number of study years. Diabetes was diagnosed based on abnormal fasting blood sugar (FBS) levels (≥126 mg/dl or 7 mmol/L), positive history of routine insulin use or oral hypoglycemic medications. Drug use including Morphine, Heroin, methamphetamine, Crack, and Cocaine once a week for at least 6 months was classified as "use of illegal/illicit drugs." People with a history of smoking less than 100 cigarettes in a lifetime were classified as "non-smokers" and, people who drank approximately 200 ml of beer or 45 ml of alcohol once a week for at least 6 months were classified as "alcoholics." To assess the participants' economic status, the wealth index was applied using the method of multiple correspondence analysis (MCA) by analyzing principal components, such as durable goods, housing features, and other facilities. The family history of hypertension was evaluated in the first and second (individuals with 25% of the genome shared with the participant) degree relatives.

A Richter aneroid sphygmomanometer was used to measure blood pressure (BP). After at least 15 min of rest, blood pressure was measured twice in the right arm at an interval of at least half an hour in a sitting position, and the mean of the two measurements was considered as the systolic and diastolic blood pressure. According to the JNC-7 criteria,[11,12] people with systolic blood pressure ≥140 mmHg, or diastolic blood pressure ≥90 mmHg, and/or a history of taking antihypertensive drugs were classified as having hypertension (reference).

Self-reports of hypertension were assessed using the following questions ("Have you ever had high blood pressure in the past?" and "Who told you that you had high blood pressure?" The second question was asked in case of a yes answer to the first question and if the person answered the second question "diagnosis by a physician," it was considered as self-reported hypertension.

Antihypertensive medicine use by participants was assessed with this question "Do you routinely use antihypertensive drugs?" A positive answer along with the visual inspection of the drugs was a confirmation of drug use by the person.

### 2.3 | Statistical analysis

Stata version 16 (StataCorp., College Station, TX, and USA) was used for the data analysis. Demographic characteristics and participants' basic information were reported as the mean (standard deviation) and percentage. The validity of the self-reported data compared with the reference criterion was expressed in terms of sensitivity as true positives correctly identified/all true positives, specificity as true negatives correctly identified/all true negatives, positive predictive values (PPV) as true positives correctly identified/all positives identified by the questionnaire, negative predictive values (NPV) as true negatives correctly identified/all negatives identified by the questionnaire, the positive likelihood ratio (LR+) as sensitivity divided by the false-positive rate (FPR), and the negative likelihood ratio (LR-) as the false-negative rate (FNR) divided by specificity. The percentage of free chance agreement (Kappa score) was used to assess the agreement between the self-reported status and hypertension diagnosis. A kappa score of less than .20 was considered as poor agreement, .20 to .40 as fair agreement, .41 to .60 as moderate agreement, .61 to .80 as substantial agreement and more than .81 as almost perfect agreement.[13] To examine the diagnostic characteristics of self-reported hypertension, we used the precision-recall curve (PRC). The PRC (a graph drawn based on sensitivity and PPV) is a diagnostic tool for two-state classification models recommended for outcomes with high skewness because, in this case, ROC curves may provide a very optimistic view of the classification tool performance.[14] Diagnostic characteristics of self-reported hypertension were investigated by a reduced model including self-reported hypertension, sex, and age in comparison with the full model including self-reported hypertension, sex, age, marital status, economic status, BMI, smoking status, drug use, alcohol use, diabetes, and family history of hypertension. Finally, 95% confidence intervals (CI) were calculated for all values based on the standard method for proportions. To explain the statistically significant predictors of concordance between self-reported hypertension and the reference, binary and multinomial logistic regressions were used. Statistical significance for all analyses was based on an alpha significance level of .05.

## 3 | RESULTS

### 3.1 | Descriptive statistics

Table 1 presents the demographic characteristics and basic information of the study participants. A total of 3976 out of 3996 participants reported information on hypertension and clinical measurements of blood pressure and/or antihypertensive drug use. Hypertension was reported by 24.50% (549) of women and 13.03% (226) of men. The mean ages of males and females were 48.78 ± 8.91 and 47.98 ± 8.92, respectively. 8.20% (325) of the participants were single, 31.19% (1245) were illiterate and only 12.78% (508) of the participants had a university education. In terms of obesity, 74.92% of participants were in an unfavorable condition (BMI = 25 or higher), 38.34% (148) of hypertensive people had diabetes at the same time, and 40.00% (1591) of the participants reported hypertension in their first-degree family (Table 1)

Among 775 people who reported hypertension (Figure 1C), 604 patients (77.93%) had a history of receiving antihypertensive drugs and/or had hypertension in clinical measurement based on NJC-7 criteria. Based on the reference criteria (Figure 1A,B), 255 patients (29.68%) were unaware of their hypertension disease. Among those who were under undertreatment (Figure 1A), hypertension was not well controlled in 186 patients (32.18%).

### 3.2 | Validity

The validity of self-reported hypertension, based on socio-demographics and some individual variables, has been shown in Table 2. The percentages of overall agreement and kappa statistics were 89.8% and 68.7%, respectively. The kappa value based on the characteristics of the population under study ranged from 54% (the lowest) to 76.8% (the highest), respectively, for the age group of 35–45 years and those without a spouse. In general, kappa agreement was higher for women, people with lower education, those with a higher economic status, ex-smokers, diabetics, and people with a family history of hypertension. The overall estimates of sensitivity and specificity for the participants were 72.0% and 94.5%, respectively. Sensitivity levels increased with an increase in age, an improvement in

**TABLE 1** Demographic characteristics and baseline information of the participants in DehPCS, by self-reported hypertension situation

| | Total *n* | Hypertension *n* (%) | Non hypertension *n* (%) | *p*-value |
|---|---|---|---|---|
| Gender | | | | |
| Male | 1735 | 226 (13.03) | 1509 (86.97) | <.001 |
| Female | 2241 | 549 (24.50) | 1692 (75.50) | |
| Age groups | | | | |
| 35–45 | 1773 | 165 (9.31) | 1608 (90.69) | <.001 |
| 46–60 | 1720 | 402 (23.37) | 1318 (76.63) | |
| >60 | 483 | 208 (43.06) | 275 (56.94) | |
| Marital status | | | | |
| Married | 3651 | 661 (18.10) | 2990 (81.90) | <.001 |
| Single | 325 | 114 (35.08) | 211 (64.92) | |
| Education years | | | | |
| Illiterate | 1245 | 413 (33.17) | 832 (66.83) | <.001 |
| 1–5 | 1110 | 184 (16.58) | 926 (83.42) | |
| 6–12 | 1113 | 123 (11.05) | 990 (88.95) | |
| University | 508 | 55 (10.83) | 453 (89.17) | |
| Economic status | | | | |
| Poor | 1344 | 204 (15.18) | 1140 (84.82) | <.001 |
| Moderate | 1300 | 265 (20.38) | 1035 (79.62) | |
| Rich | 1318 | 305 (23.14) | 1013 (76.86) | |
| BMI | | | | |
| Normal weight | 985 | 107 (10.86) | 878 (89.14) | <.001 |
| Over-weight | 1698 | 311 (18.32) | 1387 (81.68) | |
| Obese | 1281 | 353 (27.56) | 928 (72.44) | |
| Cigarette smoking | | | | |
| No smoker | 3024 | 602 (19.91) | 2422 (80.09) | <.001 |
| Ex-smoker | 239 | 87 (26.69) | 239 (73.31) | |
| Smoker | 600 | 82 (13.67) | 518 (86.33) | |
| Illegal/illicit drug use | | | | |
| No | 3502 | 701 (20.02) | 2801 (79.98) | .027 |
| Yes | 448 | 70 (15.63) | 378 (84.38) | |
| Alcohol use | | | | |
| No | 3470 | 705 (20.32) | 2765 (79.68) | .001 |
| Yes | 481 | 66 (13.72) | 415 (86.28) | |
| Diabetes | | | | |
| No | 3468 | 607 (17.50) | 2861 (82.50) | <.001 |
| Yes | 386 | 148 (38.34) | 238 (61.66) | |
| Family history of hypertension | | | | |
| No | 1315 | 161 (12.24) | 1154 (87.76) | <.001 |
| Second degree | 316 | 41 (12.97) | 275 (87.03) | |
| First degree | 1591 | 356 (22.38) | 1235 (77.62) | |
| First & Second degree | 750 | 216 (28.80) | 534 (71.20) | |

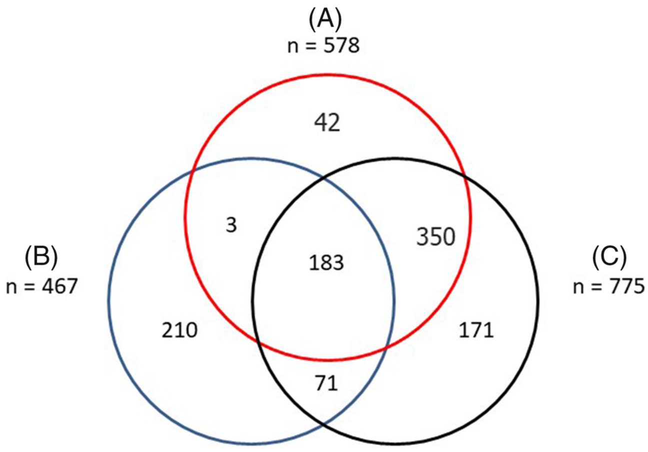


**FIGURE 1** Frequency overlap of self-reported hypertension (C) and hypertension measured by reference criteria (blood pressure measurement (B)+ treatment (A)).

economic status, an increase in BMI, and stronger family ties to people with hypertension while it decreased with an increase in the number of education years. Overall PPV and NPV were 77.9% and 92.7%, respectively. Unlike sensitivity, men had higher PPV than women. However, PPV increased with age and economic status but decreased with education years. Age with a value of 39.60% experienced the highest range of PPV changes which reached 92.30% for those over 60 years old. The value of the area under the PR curve was 79.37% for the full model (including self-reported BP, sex, age, marital status, economic status, BMI, smoking status, drug use, alcohol consumption, diabetes, and family history of hypertension) and 77.40% for the reduced model (including self-reported BP, sex, and age) (Table 2 and Figure 2).

### 3.3 | Correlates of self-reported hypertension

Table 3 shows the crude and adjusted odds ratio (OR) of the factors affecting the validity of self-reported hypertension (also see the supplement). Older age (OR = 2.28, CI: 1.69–3.09), higher BMI (OR = 1.97, CI: 1.47–2.65), and stronger family ties to hypertensive people (OR = 1.50, CI: 1.12–2.01) independently increased the disagreement between the self-reported and reference values. The results of the adjusted multinomial logistic regression suggested an increase in age, and BMI, and having a family history of hypertension increased the value of both false positive and false negative rates, independently of other factors. The false positive rate was more likely to be reported in females (OR = 2.22, CI: 1.43–4.54); conversely, males had a higher chance of reporting false negative rates (OR = 1.97, CI: 1.37–2.82). However, older age, higher BMI, concurrent diabetes, and a stronger family history of hypertension significantly increased the likelihood of a true positive report than a true negative report of hypertension.

## 4 | DISCUSSION

This study investigated the validity of self-reported hypertension in the Kurdish population. Unlike previous studies, sensitivity and specificity have been reported in the subgroups formed by the socio-demographic variables. Kappa and PPV were also reported in contrast to previous studies. The results showed the prevalence of hypertension based on self-reports and the reference criteria was 19.4% and 21.6%, respectively. The prevalence of self-reported hypertension was estimated to be close to the actual level, which was in line with the findings of the study by Najafi et al.[8] There are many reasons for the disagreement between reported and measured hypertension; for example, the reliability of BP measurements can vary according to the equipment, measurement conditions, and various subject factors such as beat-to-beat variability, bladder distention, talking, and white-coat hypertension.[15]

Our findings showed 255 patients (29.68%) were unaware of their hypertension disease, and among those under treatment, hypertension was not well controlled in 186 patients (32.18%).

In our study, the sensitivity and specificity of self-reported hypertension were 72% and 94.5%, respectively. Reports which vary by different countries have been found to be 56% and 95.5% in India,[16] 73.24% and 93.6% in China,[3] 81.7% and 98.7% in Brazil,[17] 55.5% and 91.4% in UK,[18] 73.0% and 98.5% in South Korea,[19] as well as 82.4% and 70.7% in Thailand,[20] respectively. Almost, all previous studies with large sample sizes have shown the specificity of self-reported chronic diseases was higher than their sensitivity.[13,16] Studies have shown the quality of provided health services is a reason for the differences in the validity of self-reported conditions.[19,6] Low sensitivity may be a consequence of difficulty or inability to access health services, thus it is limiting the awareness of the disease.[21] Therefore, caution should be exercised when using population data from different countries, considering regional differences, especially in terms of access to health services.

In the present study, the PPV and NPV were 77.9% and 92.2%, respectively. In a cohort study of Spanish adults, the PPV was reported to be approximately close to that of the present study (79.4%), and the NPV was 10% lower (82.8%).[22] However, another study showed the PPV and NPV of hypertension self-reporting were very different from those in the present study (the PPV and NPV were 97.3% and 57.2%, respectively).[23] The predictive value of a test will vary in different communities with different prevalences such that the lower the prevalence of a disease, the higher the NPV, and the higher the prevalence of a disease, the higher the PPV.[24] However, the use of different methods to measure self-reported hypertension in studies makes it difficult to compare results and highlights the need for standardization of methods for hypertension measurement.

Investigation of the role of factors affecting the validity of self-reported hypertension showed the disagreement between the self-reported and reference values increased with age. Consistent with the present study, the studies by Najafi et al.[8] and Delhey et al.[25] have shown in older people, differences between self-reported and examination results of hypertension increased; however, some studies have

**TABLE 2** Validity of self-reported hypertension using reference criteria in DehPCS

| | Concordance % (CI) | Kappa% (CI) | Sensitivity% (CI) | Specificity% (CI) | Specificity% (CI) | +LR | −LR | PPV% (CI) | NPV% (CI) |
|---|---|---|---|---|---|---|---|---|---|
| Overall | 89.8 (88.8–90.7) | 68.7 (65.9–71.5) | 72.0 (68.8–75.0) | 94.5 (93.7– 95.3) | 94.5 (93.7– 95.3) | 13.21 (11.35–15.37) | .30 (.27–.33) | 77.9 (74.8–80.8) | 92.7 (91.7–93.5) |
| Gender | | | | | | | | | |
| Female | 89.3 (88.0–90.6) | 70.7 (67.3–74.2) | 79.3 (75.6–82.7) | 92.4 (91.0– 93.6) | 92.4 (91.0– 93.6) | 10.38 (8.75–12.30) | .22 (.19–.26) | 76.1 (72.3–79.6) | 93.6 (92.3– 94.7) |
| Male | 90.4 (89.0–91.9) | 64.3 (59.3–69.2) | 59.6 (53.9–65.1) | 97.2 (96.2– 98.0) | 97.2 (96.2– 98.0) | 21.21 (15.42–29.17) | .42 (.36–.48) | 82.3 (76.7–87.0) | 91.7 (90.1– 93.0) |
| Age groups | | | | | | | | | |
| 35–45 | 92.4 (91.2–93.7) | 54.0 (47.2–60.7) | 60.8 (52.3–68.9) | 95.2 (94.1– 96.2) | 95.2 (94.1– 96.2) | 12.71 (9.87– 16.38) | .41 (.34–.50) | 52.7 (44.8–60.5) | 96.5 (95.5– 97.4) |
| 46–60 | 88.6 (87.1–90.1) | 69.4 (65.4–73.3) | 73.2 (68.8–77.3) | 94.0 (92.5– 95.2) | 94.0 (92.5– 95.2) | 12.13 (9.70– 15.17) | .29 (.24–.33) | 80.8 (76.7–84.6) | 91.0 (89.3– 92.5) |
| >60 | 84.3 (80.1–87.6) | 68.7 (62.4–75.1) | 76.2 (70.4–81.3) | 93.1 (89.0– 96.0) | 93.1 (89.0– 96.0) | 11.00 (6.82– 17.74) | .26 (.20–.32) | 92.3 (87.8–95.5) | 78.2 (72.8– 82.9) |
| Marital status | | | | | | | | | |
| Married | 89.8 (88.8–90.8) | 67.3 (64.2–70.3) | 69.8 (66.3–73.1) | 94.8 (93.9– 95.6) | 94.8 (93.9– 95.6) | 13.42 (11.42– 15.78) | .32 (.28–.36) | 77.0 (73.6–80.2) | 92.6 (91.6– 93.6) |
| Single | 89.5 (86.2–92.9) | 76.8 (69.5–84.2) | 86.4 (78.5–92.2) | 91.2 (86.5– 94.6) | 91.2 (86.5– 94.6) | 9.77 (6.32– 15.11) | .15 (.09–.24) | 83.3 (75.2–89.7) | 92.9 (88.5–96.0) |
| Education years | | | | | | | | | |
| Illiterate | 87.0 (85.1–88.9) | 71.7 (67.1–75.3) | 78.2 (74.1–82.0) | 91.9 (89.8– 93.7) | 91.9 (89.8– 93.7) | 9.62 (7.59– 12.21) | .24 (.20–.28) | 84.3 (80.4–87.6) | 88.3 (86.0– 90.4) |
| 1–5 | 90.5 (88.9–92.3) | 67.0 (61.1–72.8) | 69.8 (63.0–76.1) | 95.1 (93.4– 96.4) | 95.1 (93.4– 96.4) | 14.14 (10.48– 19.07) | .32 (.26–.39) | 75.5 (68.7–81.6) | 93.5 (91.7– 95.0) |
| 6–12 | 90.6 (88.8–92.4) | 54.9 (47.3–62.4) | 56.8 (47.9–65.4) | 95.1 (93.6–96.4) | 95.1 (93.6–96.4) | 11.61 (8.49 – 15.89) | .45 (.37–.55) | 61.0 (51.8–69.6) | 94.2 (92.6– 95.6) |
| University | 93.3 (91.0–95.7) | 68.6 (58.9–78.4) | 66.7 (53.7–78.0) | 97.1 (95.1–98.4) | 97.1 (95.1–98.4) | 22.82 (12.99– 40.08) | .34 (.24–.49) | 76.4 (63.0–86.8) | 95.4 (93.0– 97.1) |
| Economic status | | | | | | | | | |
| Poor | 91.4 (89.9–92.9) | 67.4 (61.9–72.9) | 70.9 (64.3–76.9) | 95.3 (93.9– 96.5) | 95.3 (93.9– 96.5) | 15.13 (11.47– 19.95) | .31 (.25–.38) | 74.0 (67.4–79.9) | 94.6 (93.1– 95.8) |
| Moderate | 89.2 (87.5–90.9) | 67.6 (62.6–72.5) | 72.6(66.9–77.7) | 93.7 (92.1– 95.1) | 93.7 (92.1– 95.1) | 11.60 (9.05 –14.86) | .29 (.24–.35) | 75.8 (70.2–80.9) | 92.7 (90.9– 94.2) |
| Rich | 89.0 (87.3–90.7) | 70.4 (66.0–74.9) | 73.3 (68.2–77.9) | 94.6 (92.9– 95.9) | 94.6 (92.9– 95.9) | 13.46 (10.28– 17.63) | .28 (.24–.34) | 82.6 (77.9–86.7) | 90.9 (89.0– 92.6) |
| BMI | | | | | | | | | |
| Normal weight | 92.6 (90.9–94.3) | 66.0 (58.8–73.2) | 62.7 (53.9–70.9) | 97.3 (96.0–98.3) | 97.3 (96.0–98.3) | 23.19 (15.18–35.43) | .38 (.31–.48) | 78.5 (69.5–85.9) | 94.3 (92.6– 95.7) |
| Over-weight | 90.5 (89.1–91.9) | 69.2 (64.7–73.6) | 72.9 (67.7–77.6) | 94.7 (93.4–95.9) | 94.7 (93.4–95.9) | 13.86 (10.9–17.53) | .29 (.24–.34) | 76.8 (71.8–81.4) | 93.6 (92.2– 94.8) |
| Obese | 86.6 (84.8–88.5) | 67.2 (62.7–71.7) | 74.5 (69.7–78.8) | 91.6 (89.6–93.4) | 91.6 (89.6–93.4) | 8.91 (7.12–11.13) | .28 (.23–.33) | 78.5 (73.8–82.6) | 89.8 (87.6– 91.6) |

(Continues)

**TABLE 2** (Continued)

| | Concordance % (CI) | Kappa% (CI) | Sensitivity% (CI) | Specificity% (CI) | Specificity% (CI) | +LR | −LR | PPV% (CI) | NPV% (CI) |
|---|---|---|---|---|---|---|---|---|---|
| Cigarette smoking | | | | | | | | | |
| No smoker | 89.8 (88.7–90.9) | 68.6 (65.3–71.9) | 73.3 (69.7–76.7) | 94.2 (93.1–95.1) | 94.2 (93.1–95.1) | 12.54 (10.61–14.83) | .28 (.25–.32) | 76.7 (73.2–80.1) | 93.1 (92.0– 94.0) |
| Ex-smoker | 88.3 (84.8–91.8) | 71.7 (63.2–89.1) | 74.3 (64.6–82.4) | 94.7 (90.9–97.2) | 94.7 (90.9–97.2) | 13.92 (7.93–24.43) | .27 (.19–.38) | 86.2 (77.1–92.7) | 89.1 (84.5– 92.8) |
| Smoker | 90.8 (88.5–93.1) | 64.9 (56.4–73.5) | 63.1 (53.0–72.4) | 96.6 (94.6–98.0) | 96.6 (94.6–98.0) | 18.45 (11.30– 30.11) | .38 (.30–.49) | 79.3 (68.9–87.4) | 92.7 (90.1– 94.8) |
| Drug use | | | | | | | | | |
| No | 89.5 (88.5–90.5) | 68.1(65.1–71.2) | 72.2 (68.9–75.4) | 94.3 (93.3–95.1) | 94.3 (93.3–95.1) | 12.57 (10.73 –14.72) | .29 (.26–.33) | 77.5 (74.2–80.5) | 92.5 (91.5– 93.5) |
| Yes | 92.4 (89.9–94.9) | 73.1 (64.5–81.6) | 72.0 (60.9–81.3) | 97.0 (94.7–98.5) | 97.0 (94.7–98.5) | 23.94 (13.17–43.51) | .29 (.20–.41) | 84.3 (73.6–91.9) | 93.9 (91.0– 96.1) |
| Alcohol use | | | | | | | | | |
| No | 89.6 (88.6–90.6) | 68.7 (65.7–71.7) | 72.8 (69.5–76.0) | 94.3 (93.3–95.1) | 94.3 (93.3–95.1) | 12.68 (10.82–14.85) | .29 (.26–.32) | 77.9 (74.6–80.9) | 92.6 (91.5– 93.5) |
| Yes | 91.7 (89.2–94.2) | 67.7 (58.4–77.1) | 66.3 (54.8–76.4) | 96.8 (94.5–98.3) | 96.8 (94.5–98.3) | 20.44 (11.71– 35.67) | .35 (.26–.47) | 80.3 (68.7–89.1) | 93.5 (90.7– 95.7) |
| Diabetes | | | | | | | | | |
| No | 90.0 (89.0–91.0) | 66.7 (63.5–69.9) | 70.0 (66.3–73.5) | 94.7 (93.8–95.5) | 94.7 (93.8–95.5) | 13.13 (11.15–15.47) | .32 (.28–.36) | 75.3 (71.7–78.7) | 93.1 (92.2– 94.0) |
| Yes | 88.3 (85.1–91.6) | 75.6 (68.8–82.3) | 83.2(76.4–88.7) | 91.8 (87.5–95.0) | 91.8 (87.5–95.0) | 10.12 (6.54–15.66) | .18 (.13–.26) | 87.2 (80.7–92.1) | 89.1 (84.4– 92.7) |
| Family history of hypertension | | | | | | | | | |
| No | 90.1 (89.1–92.2) | 62.1 (56.0–68.1) | 58.8 (51.9–65.4) | 96.9 (95.7– 97.8) | 96.9 (95.7– 97.8) | 19.01 (13.40–26.95) | .43 (.36–.50) | 78.9 (71.8–84.9) | 92.3 (90.6– 93.8) |
| Second degree | 92.7 (89.8–95.6) | 66.7 (54.0–79.0) | 73.7 (56.9–86.6) | 95.3 (92.1– 97.5) | 95.3 (92.1– 97.5) | 15.76 (8.9 –27.69) | .28 (.16–.47) | 68.3 (51.9–81.9) | 96.4 (93.4– 98.2) |
| First degree | 89.6 (88.0–91.0) | 70.1 (66.7–75.0) | 75.2 (70.5–79.5) | 94.1 (92.7– 95.4) | 94.1 (92.7– 95.4) | 12.84 (10.17– 16.20) | .26 (.22–.31) | 80.1 (75.5–84.1) | 92.4 (90.8– 93.8) |
| First & second degree | 87.5 (85.1–89.8) | 68.9 (63.0–74.7) | 79.9 (73.7–85.2) | 90.3 (87.5– 92.6) | 90.3 (87.5– 92.6) | 8.23 (6.32– 10.73) | .22 (.17–.29) | 75.5 (69.2–81.0) | 92.3 (89.7– 94.4) |

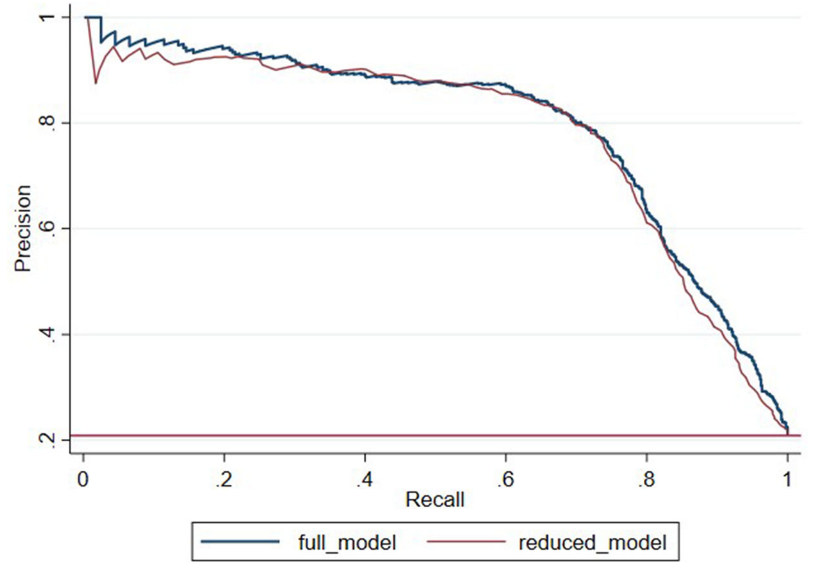


**FIGURE 2** Diagnostic characteristics of the reduced model (self-reported hypertension, sex, age) in comparison with the full model (Self-reported hypertension, sex, age, marital status, economic status, BMI, smoking status, drug use, alcohol use, diabetes, and family history of hypertension).

found higher agreement often in older populations.[19,26] In general, elderly people tend to have more frequent contacts with the health-care system. Therefore, they might be better informed about their chronic conditions than younger individuals.[26] However, the higher specificity of self-reporting compared to its sensitivity and the increase in the prevalence of chronic age-related diseases can be considered as a reason for the reduced self-report validity in the elderly.[8] Recall bias may be a particular concern when interpreting survey responses given by the elderly and they may both over- and under-report their self-reported responses.[27]

Disagreement increased with BMI for both false-positive and false-negative results. Najafi et al., similar to the present study, showed the positive and negative values of self-reported hypertension increased with increasing BMI.[8] In a study by Bhatia et al. in India, sensitivity was higher in obese individuals.[16] The observed result may be related to less use of health care, worse lifestyle habits, and consequently, less health awareness in obese participants. In contrast, Hunger and Major found BMI was indirectly related to poorer self-reported health through its effect on perceived discrimination and concerns about stigma.[28]

At the univariate level, the chance of discordance in participants with a university education was less than that in illiterate participants. Similar results were shown in studies by Ning et al.,[26] Bhatia et al.,[16] and Chun et al.[19]; however, the results of de Menz et al.'s[23] study are in contrast to those of our study.

Exploring the effect of a family history of hypertension on the accuracy of self-reported hypertension shows the chance of disagreement is higher in people whose first- and second-degree relatives have hypertension than in those without a family history of hypertension. A similar result was seen only in Najafi et al.'s study,[8] and other studies have shown family history is associated with more accurate self-reporting.[13,28] The disease presence in the members of a family may be due to the fact that these people have an unhealthy lifestyle and usually do not seek to evaluate their health status. Therefore, these individuals are less likely to seek health care and are not aware of their health status.[29,30]

In the present study, disagreement and false positives for self-reported hypertension in single people were higher than those in married individuals. A study in Brazil found people with a partner were more sensitive to self-reported hypertension than those without a partner.[31] However, a study on Oman adults showed the difference between self-reporting and measuring hypertension was greater among married people than single ones.[32] It is possible that married people, due to the influence of their partners, have more follow-up and awareness about their health status, so a higher concordance on self-reported hypertension is acceptable in this group.

Investigation on gender roles in the observed inconsistency showed like other studies, false positive reports were more frequent in women than in men, but false negatives were more common in men than in women, which is consistent with the findings of other studies.[9] The high false-positive value in women can be attributed to the fact that women use health services more than men[32] and may be more willing to take preventive health actions because of their lifetime increased contacts with health care professionals for their reproductive health care.[33]

In our study, sensitivity and PPV were higher in patients with diabetes than those without diabetes. It is possible that individuals with other comorbidities undergo a greater number of medical visits, thus it is increasing the likelihood of hypertension diagnosis.[34] In addition, the known risks of comorbidities encourage patients to be more concerned about their health and are therefore more likely to seek medical care.

Analyses showed the agreement between self-reported and measured BP was higher in smokers than in ex-smokers and non-smokers, but they had lower sensitivity. Less sensitivity in current smokers than in non-smokers in the study by Chun et al. was also observed.[19] Some studies have shown the short-term effect of smoking on hypertension, and this could be the reason for the low sensitivity observed in the

**TABLE 3** Univariable and multivariable analysis of factors affecting the validity of self-reported hypertension in DehPCS

| | Disagreement self-reported [a] | | False negative self-reported[b] | | False positive self-reported[b] | | True positive self-reported[b] | |
|---|---|---|---|---|---|---|---|---|
| Variables | Crud OR (CI) | Adjusted OR[c] | Crud OR | Adjusted OR[d] | Crud OR | Adjusted OR[d] | Crud OR | Adjusted OR[d] |
| Gender | | | | | | | | |
| Female | 1 | – | 1 | 1 | 1 | 1 | 1 | 1 |
| Male | .88 (.72–1.09) | – | .35 (.24–.50)*** | .45 (.29–.70)*** | 1.32 (1.01–1.73)* | 1.97 (1.37–2.82)*** | .51 (.42–.61)*** | .81 (.62–1.06) |
| age | | | | | | | | |
| 35–45 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 46–60 | 1.57 (1.25–1.98)*** | 1.55 (1.23–1.96)*** | 1.28 (.92–1.77) | 1.40 (.95–2.06) | 2.75 (1.98–3.81)*** | 2.38 (1.64–3.45)*** | 4.83 (3.77–6.20)*** | 4.09 (3.07–5.46)*** |
| >60 | 2.28 (1.69–3.09)*** | 2.49 (1.82–3.39)*** | 1.48 (.85–2.58) | 2.29 (1.19–4.42)* | 7.73 (5.23–11.43)*** | 7.23 (4.39–11.89)*** | 15.93 (11.91–21.30)*** | 19.90 (13.59–29.14)*** |
| Marital status | | | | | | | | |
| Married | 1 | – | 1 | – | 1 | – | 1 | – |
| Single | 1.03 (.71–1.49) | – | 1.77 (1.07–2.91)* | – | .96 (.56–1.66) | – | 2.64 (2.03–3.43)*** | – |
| Education years | | | | | | | | |
| Illiterate | 1 | | 1 | 1 | 1 | 1 | 1 | 1 |
| 1–5 | .70 (.54–.91)** | – | .59 (.40–.87)** | .78 (.50–1.20) | .52 (.37–.73)*** | .67 (.45–.99)* | .34 (.27–.42)*** | .65 (.49–.85)** |
| 6–12 | .70 (.54–.91)** | – | .58 (.39–.55)** | 1.04 (.63–1.70) | .46 (.33–.65)*** | .70 (.44–1.12) | .17 (.13–.22)*** | .56 (.39–.80)*** |
| University | .48 (.33–.70)*** | – | .34 (.18–.62)*** | .66 (.32–1.39) | .37 (.23–.60)*** | .54 (.29–1.00) | .21 (.15–.29)*** | .67 (.43–1.06) |
| Economic status | | | | | | | | |
| Poor | 1 | – | 1 | – | 1 | – | 1 | – |
| Moderate | .98 (.76–1.26) | – | 1.03 (.70–1.51) | – | .90 (.68–1.23) | – | .83 (.69–1.03) | – |
| Rich | .83 (.64–1.06) | – | .96 (.67–1.39) | – | .62 (.45–.87)** | – | .56 (.45–.70)*** | – |
| BMI | | | | | | | | |
| Normal weight | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Over-weight | 1.31 (.98–1.75) | 1.37 (1.19–1.96)* | 2.00 (1.28–3.22)** | 1.64 (1.01–2.68)* | 1.13 (.79–1.62) | 1.40 (.95–2.06) | 1.81 (1.39–2.36)*** | 1.95 (1.44–2.64)*** |
| Obese | 1.92 (1.44–2.57)*** | 1.97 (1.47–2.65)*** | 3.28 (2.04–5.29)*** | 2.32 (1.41–3.82)*** | 1.89 (1.32–2.69)*** | 2.76 (1.86–4.10)*** | 3.28 (2.52–4.26)*** | 3.54 (2.60–4.84)*** |

(Continues)

**TABLE 3** (Continued)

| | Disagreement self-reported [a] | | False negative self-reported [b] | | False positive self-reported [b] | | True positive self-reported [b] | |
|---|---|---|---|---|---|---|---|---|
| Variables | Crud OR (CI) | Adjusted OR [c] | Crud OR | Adjusted OR [d] | Crud OR | Adjusted OR [d] | Crud OR | Adjusted OR [d] |
| Cigarette smoking | | | | | | | | |
| No smoker | 1 | – | 1 | – | 1 | – | 1 | – |
| Ex-smoker | 1.16 (.81–1.67) | – | .91 (.49–1.66) | – | 1.64 (1.06–2.53)* | – | 1.72 (1.30–2.28)c | – |
| Smoker | .89 (.67–1.20) | – | .57 (.34–.95)* | – | 1.06 (.74–1.53) | – | .66 (.50–.87)** | – |
| Drug use | | | | | | | | |
| No | 1 | – | 1 | – | 1 | – | 1 | – |
| Yes | .70 (.49–1.01) | – | .51 (.27–.95)* | – | .80 (.51–1.25) | – | .79 (.59–1.06) | – |
| Alcohol use | | | | | | | | |
| No | 1 | – | 1 | – | 1 | – | 1 | – |
| Yes | .78 (.56–1.10) | – | .55 (.31–.98)* | – | .87 (.57–1.32) | – | .64 (.47–.86)** | – |
| Diabetes | | | | | | | | |
| No | 1 | – | 1 | 1 | 1 | 1 | 1 | 1 |
| Yes | 1.19 (.86–1.66) | – | 1.59 (.97–2.62) | 1.37 (.82–2.29) | 1.67 (1.08–2.57)* | 1.15 (.73–1.80) | 3.55 (2.79–4.51)*** | 2.15 (1.63–2.83)*** |
| Family history of hypertension | | | | | | | | |
| No | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Second degree | .76 (.48–1.21) | .87 (.54–1.40) | 1.54 (.80–2.95) | 1.74 (.89– 3.38) | .45 (.23–.88)* | .68 (.33–1.40) | .87 (.57–1.36) | 1.70 (1.04–2.76)* |
| First degree | 1.12 (.88–1.43) | 1.17 (.92–1.51) | 1.95 (1.28–2.96)** | 1.97 (1.29–3.03)** | .98 (.73–1.33) | 1.34 (.97–1.87) | 2.09 (1.67–2.62)*** | 3.24 (2.48–4.22)*** |
| First & Second degree | 1.39 (1.04–1.85)* | 1.50 (1.12–2.01)** | 3.37 (2.16–5.25)*** | 3.39 (2.14–5.38)*** | .99 (.68–1.46) | 1.64 (1.08–2.49)* | 2.77 (2.15–3.58)*** | 5.21 (4.84–7.08)*** |

[a] Logistic regression.
[b] Multinomial logistic regression with true negative self-reported hypertension as a reference category.
[c] Model adjusted for age, BMI, and family history of hypertension.
[d] Model adjusted for gender, age, education years, BMI, diabetes, and family history of hypertension.
*$p$-value < .05, **$p$-value < .01, ***$p$-value < .001.

smoker group.[35] On the other hand, more medical visits due to complications caused by smoking lead to an increase in the awareness of hypertension, and increased awareness leads to greater agreement between self-reporting and measurement of results.

In this study, we used the PRC instead of the ROC curve to represent the classification of individuals based on their self-reports against the standard criterion. The value of the area under the PRC was 79.79% for the full model and 77.40% for the reduced model, which indicated a very high effect of sex and age compared to other variables on the accuracy and remembering of self-reported BP.

### 4.1 | Strengths and limitations

In fact, the diagnosis of hypertension must be based on several separate measurements because the reliance on two measurements taken during a single physical examination instead of multiple measurements over longer time intervals may have led to biased estimates of the disease prevalence.[36] White-coat hypertension is a situation in which the blood pressure in the clinic is higher than normal while outside the clinic, the blood pressure is settled to the normal range. This causes some people to be mistakenly considered to have high blood pressure. In this study, some participants with nocturnal hypertension may be missed. The study results should be cautiously generalized to other provinces of Iran, which have ethnicities with different cultures.

Despite these limitations, the present study has several strengths. The analyses were based on a large sample size and a regionally-representative sample. The use of high-quality cohort data, and trained researchers to collect data are some of its strengths while the response rate in this study is high (the response rate of 91% in the baseline). Our samples also were participants aged 30–70 years, and included a large proportion of people at high risk of hypertension. Identifying the characteristics influencing on the accuracy of hypertension measurement in these age groups can reduce the problems of hypertension diagnosis.

## 5 | CONCLUSION

Our study indicated the reported value overestimated true prevalence. However, the self-reported hypertension had good validity and seemed to have a relatively good ability to identify patients with hypertension. High PPV especially in people over 60 years old indicated those who reported having high blood pressure were very likely to really suffer from hypertension. Therefore, in underserved areas in terms of primary health care, it is possible to rely on people's self-reporting and take the necessary measures to prevent complications in clinical practice. However, self-reporting could be used as a suitable tool for patient screening (especially for the elderly). Self-reported hypertension measurement is a simple and low-cost method which does not require extensive training and complex equipment. This method of data collection can be used as an important strategy for continuous population monitoring, policymaking, and policy assessment to reduce the disease burden.

## AUTHORS CONTRIBUTION

NP, EF, and RGG: data collection and manuscript preparation; YM and MA: study conceptualization; FM: study design; FM and RGG: final revision and grammar editing; FM and YM: statistical analyses.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict interests.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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