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Abstract

Background: High-normal blood pressure (HNBP) has become associated with a 2–3-fold increase in the risk of developing hypertension. Cardiovascular diseases (CVDs) are independently linked to HNBP.

Aims: To estimate the prevalence of HNBP, its predictors, and association with CVD risk among a country-representative sample of Egyptian adults.

Methods: This study draws on data from the most recent Egyptian Health Issues Survey, and includes 13 983 adults aged 18–59 years. Sociodemographic data and anthropometric and blood pressure (BP) measurements were obtained, and the 10-year cardiovascular risk score was calculated using World Health Organization CVD risk charts for participants aged ≥ 40 years.

Results: Overall, 15.31% and 21.0% of the study population had HNBP and hypertension, respectively. Compared to people aged 18–30 years, the odds of HNBP were 1.36, 1.67 and 2.39 among those aged 31–40, 41–50 and 51–59 years, respectively. The odds of HNBP were higher among male, overweight and obese adults, and patients with diabetes. The odds of HNBP and hypertension were higher among participants with high WHO CVD risk than those with low WHO CVD risk.

Conclusion: HNBP is an alarming risk factor among Egyptian adults because it is strongly associated with CVD risk. Policy-makers should devise long-term, effective strategies for its

prevention and control.

Keywords: cardiovascular disease, hypertension, high-normal blood pressure, risk factors, Egypt.

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Introduction

High-normal blood pressure (HNBP) is a state of elevated blood pressure not reaching the cutoff for diagnosis of hypertension. To describe this state, several terms have been used, such as prehypertension and borderline hypertension. The latest is HNBP, which was coined to draw public attention to this rising health problem. Its prevalence in population-wide studies ranges between 22 and 46% (1,2). HNBP has become associated with a 2–3-fold increase in the risk of developing hypertension, as reported in a recent meta-analysis of longitudinal studies with follow-up period of 2–8 years (3). In the Framingham study, 37% of individuals with prehypertension aged 65 years developed hypertension within 4 years (4). In the TROPHY study, among prehypertension patients in the placebo group aged 30–65 years, 63% developed hypertension over a 4-year period, while > 40% progressed over 2 years (5). Prehypertension in the above studies had a wider range than HNBP. Prehypertension is generally defined as systolic BP (SBP) 120–139 mmHg and/or diastolic BP (DBP) of 80–89 mmHg (6).

Cardiovascular diseases (CVDs) are the leading causes of death worldwide and are independently linked to HNBP, with a 3.5-fold increased risk for myocardial infarction and 1.7-fold increase for coronary artery disease (1,3). One third of CVDs are attributed to HNBP, irrespective of associated comorbidity (3). In the most recent meta-analysis of 29 studies with a total population of 491 666, those with prehypertension showed an increased risk of CVD compared to individuals with normal BP, with a population attributable risk of 12.09% (2). These

results were reported from studies conducted in the United States of America (USA), Europe and Asia. However, only the Islamic Republic of Iran from the Middle East and North Africa Region studied this association nationwide and reported prehypertension prevalence as 39.5%, and after 10 years of follow-up, it reported a relative risk of 1.74 for CVD (7).

In an endeavour to raise public awareness of HNBP and bring healthcare providers' attention to at-risk individuals, most recent hypertension guidelines have added a separate class for HNBP, with variable cutoff values (Table 1) (6,8–10). Despite growing evidence supporting that tight control of SBP could decrease CVD in prehypertensive patients with high cardiovascular risk (11), the treatment strategies are divergent. The European Society of Cardiology and the European Society of Hypertension (ESC/ESH) do not endorse pharmacological treatment for HNBP (9), whereas the American College of American Heart Association (ACC/AHA) recommend it for patients with high cardiovascular risk score (10). The World Health Organization (WHO) recommends antihypertensive drug treatment for individuals with existing CVD or high cardiovascular risk, diabetes mellitus, or chronic kidney disease, and SBP of 130–139 mmHg in the Guidelines for the Pharmacological Treatment of Hypertension in Adults (12).

In Egypt, the most recent national hypertension guidelines (2019) which have abeen dopted by the Egyptian Hypertension Society Guidelines (2014) do not include the HNBP category (8). This could be to embrace the latest evidence while measuring the economics and cost-effectiveness of the interventions (13). The magnitude of the HNBP prevalence and associated risks are yet to be thoroughly investigated in Egypt, and therefore the main purpose of this study was to estimate the population-wide prevalence of HNBP, its predictors, and associated cardiovascular risk within the Egyptian context. This results may yield deeper insights for the national hypertension guidelines in Egypt.

Methods

Data source

The source of data for this study was the 2015 Egyptian Health Issues Survey (EHIS); a country-representative survey that focused on noncommunicable diseases, cardiovascular risk factors, smoking, obesity, viral hepatitis, and women's health issues. The EHIS was conducted from September 2014 to September 2015 by El-Zanaty and associates (14).

Study design and sampling

The EHIS followed a multistage stratified cluster sampling technique and took advantage of the sample developed for the Egypt Demographic Health Survey (DHS 2014). Firstly, the sample frame was defined, in which rural and urban neighbourhoods were the primary sampling units

(PSUs), yielding a total of 6289 units [54% urban (shiakha), 46% rural (village)]. This list was obtained from the Central Agency for Public Mobilization and Statistics. Secondly, the DHS 2014 proportionately selected 884 PSUs, for a total household population of 29 172 (15 015 urban and 14 157 rural). Finally, a proportionate and systematic random selection of 614 PSUs for the EHIS 2015 was made autonomously as a subsample from the available list of DHS 2014. For each PSU, 1–3 parts were selected according to the unit and population size; for each part, and 1 segment was randomly selected. For each segment, the household list was used to perform the systematic random sampling that led to the study sample. The details of sampling procedures and survey techniques are detailed in the EHIS report (13), which is publicly available.

Study population and sample size

The response rate to the EHIS was 97.02% for respondents aged 15–59 years. We included data of respondents aged 18–59 years, excluded pregnant women and individuals with missing BP or body mass index (BMI) measurements (n = 1015). The final number included for this analysis was 13 983. Only people aged ≥ 40 years were included in the cardiovascular risk analysis (n = 5160). Details on study sampling and flow are illustrated in Figure 1 .

BP measurement and classification

For the EHIS survey, respondents were asked if they had ever been told by a physician that they had hypertension (once or on several occasions and if they were on medication or lifestyle advice). The trained interviewer first checked any recent coffee or tea drinking or smoking in the past 30 minutes, then they measured BP in triplicates with 10-minute intervals between each measurement, using a fully automatic digital BP monitor with upper arm automatic inflation (15). An appropriate cuff was used based on arm circumference. The first reading was discarded and the average of the last 2 readings was kept as the participant's BP measurement.

Participants were classified into 3 according to their hypertension diagnostic history and BP measurement according to National Hypertension Guidelines 2019 (8) and ESC/ESH 2018 (9) as follows: hypertension: a history of hypertension diagnosis or BP ≥ 140/≥ 90 mmHg; HNBP: BP 130–139/85–89 mmHg; and normal BP: BP **Assessment and classification of cardiovascular risk**

We assessed the 10-year cardiovascular risk using the non-laboratory version of the 2019 WHO risk charts (16) specific for the Middle East and North Africa. This version is recommended when diabetes and cholesterol cannot be measured since it uses age, sex, smoking status, SBP and BMI to calculate the regional specific 10-year cardiovascular risk. The recommended minimum age of calculation using this version is 40 years, and hence for our analysis, we calculated the cardiovascular risk for participants aged ≥ 40 years (17). The 10-year

cardiovascular risk is categorized according to the WHO charts into 5: 30%, taking the colour of green, yellow, orange, red and dark red, respectively. CVD risk category > 20% is high risk (18).

Measurement of body weight and height

A portable stadiometer and a lightweight digital scale were used to measure the participants' height and weight. BMI was calculated and the WHO classification of BMI was used (**Statistic al analysis**

Data were retrieved from the DHS website and analysed using Stata version 16. Descriptive statistics were mean, median, standard deviation (SD), and interquartile range for continuous variables after the normality check, and frequencies of categorical variables. For calculating the country-specific CVD risk, we used a special Stata program "whocvdrisk" (https://www.phpc.cam.ac.uk/ceu/erfc/programs/). The $\chi 2$ test was used to assess bivariate association between BP categories and other categorical variables. One-way analysis of variance and Kruskal–Wallis tests were used to test mean age and median WHO CVD risk score across BP groups, respectively. Significantly associated variables with BP categories were further assessed using unadjusted and adjusted multinomial logistic regression models. As the sample was not a simple random sample, the complex sample design (strata and sample weights) was incorporated in all the analyses. This is a recommended essential procedure to compensate for the under- or over-sampling of different strata during the sample selection. Weighted percentages were reported as well as survey corrected $\chi 2$, regression coefficient and confidence intervals. Significant level was set at P **Results**

The total number of respondents who met the inclusion criteria was 13 983. The mean (SD) age was 35.8 (11.6) years; 62.9% were Table 2). Half of the population were employed. Most of the study population (72.5%) were nonsmokers while 23.4% were current everyday smokers and 4.1% ex-smokers. There were 25% in the normal BMI category and 42.8% and 30.6% in the obese and overweight categories, respectively. A history of diabetes mellitus (DM) was present in 5.5%.

HNPB and hypertension were observed in 15.3% and 21% of the population, respectively. In the population aged > 40 years, 17% had WHO CVD risk estimation > 20%.

Table 2 shows the bivariate association of these demographic and medical characteristics with BP categories; age, gender, marital status, residence, educational attainment, employment, BMI, DM, previous heart attack, stroke and WHO CVD risk were significantly associated with BP categories.

Table 3 shows the results of the unadjusted and two-adjusted multinomial regression models of association of risk factors with normal BP, HNBP and hypertension. The normal BP category was kept as the base or reference. In the first adjusted model, age, gender, BMI categories and DM were associated with both HNBP and hypertension, while marital status and residence were associated with HNPB but not with hypertension. Compared to participants aged 18–30 years, the odds of HNPB were higher among those aged 31–40 years [odds ratio (OR) 1.36; 95% confidence interval (CI) 1.14–1.63], 41–50 years (OR 1.67; 95% CI 1.37–2.03) and 51–59 years (OR 2.39; 95% CI 1.91–2.99). Compared to women, men had greater odds of having HNBP (OR 1.52; 95% CI 1.23–1.89). Ever married participants were 21% less likely to have HNPB than married participants (OR 0.79; 95% CI 0.64–0.96). Compared to rural residents, urban residents were less likely to have HNPB (OR 0.77; 95% CI 0.66–0.89). Compared to the normal BMI category, the odds of HNBP were higher for overweight (OR 1.3; 95% CI 1.1–1.6) and obesity (OR 1.7; 95% CI 1.5–2.0). Participants with diabetes had higher odds of HNBP (OR 1.4; 95% CI 1.1–2.0). Participants with a history of stroke had no significant association with HNBP. Participants with hypertension and a history of stroke had higher odds of HNBP (OR 20.6; 95% CI 5.3–80.3), although this association should be interpreted with caution given the wide CI, denoting less precision.

In the second adjusted multinomial regression model, the odds of HNBP and hypertension were greater among participants with high WHO CVD risk (OR 4.52; 95% CI 3.14–6.50) compared to those with low WHO CVD risk (OR 19.15; 95% CI 13.08–28.05).

Discussion

This is the first study of its kind to investigate the prevalence of HNBP, what causes it, and how it is related to CVD risk in a large representative sample of Egyptian adults. Previous research focused only on the prevalence of hypertension in 1995 (20) or awareness of hypertension in 2020 (21). Traditionally, the Egyptian health system and the national clinical guidelines do not consider HNBP and there is a debate about whether to consider it for economic and cost-effectiveness concerns (8, 13). The use of the most recent WHO CVD risk chart, specific to the country and region, was another strength.

The prevalence of HNBP among the Egyptian population was 15.31%, which is similar to the prevalence from a Romanian population study in 2020 (11%) (22). It is notably less than that reported in a meta-analysis of many countries in Asia and Europe and the USA in 2013 (25.2–46.0%) (23). The highest prevalence of HNBP was documented in Saudi Arabia (54.9%) and Nigeria (58.7%) (24, 25), which can be explained by the multiple definitions of HNBP. This study used Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure guidelines with SBP of 120–139 mmHg and/or DBP of 80–89 mmHg

representing prehypertension (6). (Table 1)

The mean age of the HNBP group was 36.99 (11.33) years, which is significantly different from that of the normal BP (HNBP group had higher mean age) and hypertension (HNBP group had lower mean age) groups. It was similar to the mean age reported in the Turkish study [37.42 (13.03) in men and 37.80 (12.87) in women] (26), but it was markedly lower than the mean age in most of the published literature, such as studies in China [49.0 (15.4) years] (27), Japan (59 years) (28) and Germany (59.2) years (29). This can be explained by the lower mean age of the Egyptian population than the European and Asian populations and because the maximum age included in our study was 59 years. It may also indicate that early detection of HNBP is mandatory for the prevention of further complications in later life.

Gender had a significant association with BP categories. In the whole population, the prevalence of HNBP in men was 18.10% and 12.96% in women (among HNBP individuals, 54.06% were male). This was in agreement with the studies in Turkey (16.8% in men and 12.6% in women) (26) and Romania (13.8% in men and 8.4% in women) (22) but not as high as that reported in an American study (44.8% in men and 27.3% in women) (30). The male predominance observed in the HNBP group could have been due to the CV protective effects of estrogens and accompanying vascular relaxation in women (31).

The ever-married individuals represented 80.96% of the HNBP group, which is similar to that in Turkey (80.54%) (26). Educational level and occupation were significantly associated with HNBP. Among the participants with HNBP, 50.75% attended up to secondary school, which agrees with a Chinese study in which medium education levels (middle and high school) increased the risk of prehypertension (27), but disagrees with a Turkish study in which prevalence of prehypertension was inversely related to educational level (26). In the HNBP group, 55.86% were employed, which agrees with other studies (26) and reflects the level of stress accompanying certain occupations.

About 67.24% of HNBP individuals were living in rural areas, which contrasts with 37.1% in China (27) and 49.4% in Nigeria (25). This could be attributed to the educational level in rural areas where secondary school is the predominant highest level of education compared to urban areas, where higher education is predominant.

In this study, smoking and obesity were explored as risk factors for HNBP. Smoking was significantly correlated with BP status. Nearly one-third of people in the HNBP group were

smokers or ex-smokers. This inverted relationship with smoking was also revealed in previous studies (26) and others did not detect a significant correlation with smoking (22, 27). The proportion of participants with HNBP showed a significant steady increase correlated with BMI (22.45% in normal weight, 32.57% in overweight and 43.77 in obesity), affirming the robust correlation of BMI and HNBP observed in other studies (22, 25–27). As for associated comorbidities, like other studies, DM, previous heart attack or myocardial infarction, and stroke were all significantly correlated with HNBP (22, 32).

CVD risk, as a major concern in our study, showed a significant association with BP. CVD risk score of 10–20% and ≥ 20% was reported in 52% and 20% of participants with HNBP aged ≥ 40 years, respectively. This showed a similar pattern to the hypertension group but was significantly higher than in the normal BP group. This is consistent with other studies (22, 23, 27), and this shows that HNBP is worthy of research and attention, to lessen the burden of cardiovascular diseases.

Adjusted regression for all significantly associated variables was completed. Age was a strong predictor with a greater likelihood of developing HNBP as the age increased, as observed in other studies (22, 25–27). Some studies showed a decrease in prevalence after the age of 70 years, which could have been due to conversion to hypertension (26). As in other studies, men had greater odds than women of having HNBP (22, 25–27), which could have been due to increased sympathetic activity in middle-aged men (33), as well as the cardioprotective effects of estrogen in women (31). Marriage, urban residence and smoking seemed to have a protective effect on HNBP, which confirmed the unclear controversial relation with smoking observed in Romania (22). Overweight and obesity were strong predictors, with 33% and 72% greater odds of developing HNBP, as reported in a meta-analysis conducted in 2015 studying the situation in many countries in Asia, Europe, and the USA (3) and in a study in Romania (22). DM was a significant predictor, with 44.0% increased odds of having HNBP, which was also observed in the Korean Genome and Epidemiology Study (34) and in an Iranian prospective study (35).

Our study revealed a strong association between CVD risk and HNBP; compared to low CVD risk, individuals with high risk had 4.5-fold increased odds of having HNBP compared to individuals with normal BP. This finding is consistent with other studies (3, 22, 23, 27). Considering the young mean age in the HNBP group [36.99 (11.33) years], and the increased risk of progression to hypertension, individuals with HNBP are vulnerable to increased CVD risk.

The main limitations of this study were as follows. First, the cross-sectional nature of the study did not allow us to investigate the causal relationships. Second, use of BP readings from one

setting may have overestimated BP. Third, we used the non-laboratory version of the WHO CVD chart due to unavailability of test results for cholesterol and blood sugar. Further randomized controlled trials and longitudinal studies are still required to decide the best strategy to manage and control HNBP.

Conclusion

HNBP is an alarming issue with a prevalence of 15.31% among the adult Egyptian population, and it is strongly associated with a high risk of CVD. The public should be aware of the importance of leading a healthy, less-stressful lifestyle to prevent HNBP, obesity, DM and other modifiable CVD risk factors. Decision-makers and policy-makers should develop long-term strategies for HNBP prevention and control and stopping its progression to hypertension. One of these strategies is to address HNBP in the national clinical guidelines for management of hypertension. The WHO recommendations could be a useful source for balancing population health benefits and cost-effectiveness.

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Competing interests: None declared.

Prévalence et déterminants de la pression artérielle normale, normale haute et de l'hypertension et association avec le risque cardiovasculaire en Égypte

Résumé

Contexte : La pression artérielle normale haute est désormais associée à un risque deux à trois fois plus élevé de développer une hypertension. Les maladies cardiovasculaires (MCV) sont indépendamment liées à la pression artérielle normale haute.

Objectifs : Estimer la prévalence de la pression artérielle normale haute, ses facteurs prédictifs et l'association avec le risque de MCV dans un échantillon d'adultes égyptiens représentatif du pays.

Méthodes : La présente étude s'appuie sur les données de la plus récente enquête égyptienne sur les problèmes de la santé, et inclut 13 983 adultes âgés de 18 à 59 ans. Des données

sociodémographiques et des mesures anthropométriques ainsi que des mesures de la pression artérielle ont été obtenues, et le score de risque cardiovasculaire à 10 ans a été calculé à l'aide des tableaux de risque de MCV de l'Organisation mondiale de la Santé pour les participants âgés de 40 ans et plus.

Résultats : Au total, 15,31 % et 21 % de la population de l'étude présentaient respectivement une pression artérielle normale haute et une hypertension. Par rapport aux personnes âgées de 18 à 30 ans, les risques liés à une pression artérielle normale haute étaient de 1,36, 1,67 et 2,39 respectivement chez les personnes âgées de 31 à 40 ans, 41 à 50 ans et 51 à 59 ans. Les risques liés à une pression artérielle normale haute étaient plus élevés chez les hommes, les adultes en surpoids et obèses et les patients diabétiques. Les risques liés à une pression artérielle normale haute et une hypertension étaient plus élevés chez les participants présentant un risque de MCV élevé selon l'OMS que chez ceux présentant un faible risque.

Conclusion : La pression artérielle normale haute est un facteur de risque alarmant chez les adultes égyptiens car elle est fortement associée au risque de maladie cardiovasculaire. Les responsables de l'élaboration des politiques doivent concevoir des stratégies efficaces à long terme pour prévenir et maîtriser cette maladie.

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