Long-term Trends in Hypertension Prevalence, Awareness, Treatment, and Control Rate in the Middle East and North Africa: a Systematic Review and Meta-analysis of 178 Population-Based Studies

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Abstract

Purpose of Review This study investigated and pooled the long-term trends in prevalence, awareness, treatment, and control of hypertension (HTN) in the Middle East and North Africa (MENA) region. In this systematic review and meta-analysis, we searched MEDLINE/PubMed, Web of Science, Google Scholar, EMBASE, and Scopus between database inception and November 2020. All cross-sectional studies that investigated the prevalence of pre-HTN, HTN, awareness, treatment, and control in the MENA counties were included. The selection study, data extraction, and quality assessment were conducted by two investigators independently. Heterogeneity between studies was assessed using Cochran's Q test and I-squared, and due to sever heterogeneity between studies, the random effect model was used to pool the estimates. Sensitivity analysis was performed to estimate the long-term trends in prevalence, awareness, treatment, and control rates of HTN according to definition of HTN as systolic blood pressure of 140 mm Hg or more, or diastolic blood pressure of 90 mm Hg or more, or being on pharmacological treatment for HTN.

Recent Findings Overall, 178 studies met the inclusion criteria. Studies comprised 2,262,797 participants with a mean age of 45.72 ± 8.84 years. According to random effect model, the pooled prevalence of pre-HTN and HTN was 33% (95% CI 28, 39) and 26% (25, 27), respectively. Over the past three decades, prevalence of hypertension increased significantly in the region. The pooled awareness, treatment, and control rates were 50% (48, 53), 41% (38, 44), and 19% (17, 21), receptively. The pooled awareness, treatment, and control rates of HTN were lower significantly in men than women. According to definition of HTN as blood pressures above 140/90 mm Hg, over the past three decades, although the awareness and treatment rates did not change significantly, the control rates improved significantly in the region.

Summary The findings showed that HTN is a significant public health problem in the MENA region. Although there are low levels of pooled awareness, treatment, and control rates, the control rates improved over the past three decades in the region.

Keywords Pre-hypertension · Blood pressure · Hypertension · Awareness · Treatment · Control · Middle East and North Africa region

Introduction

Hypertension (HTN) remains one of the significant risk factors for multiple complications such as stroke, coronary artery diseases, and renal failures [1]. Despite the efforts in managing

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HTN across the globe in recent years, a surge in the prevalence of the condition has been observed [2]. This remains a major public health concern, especially in low- and middle-income countries. Proper management of HTN leads to lower health complications for patients, as well as less burden on the health care system. Recent findings have shown an HTN prevalence rate of 17.5% in low- and middle-income countries. However, only 29.9% of these patients have received treatment for HTN and only 10.3% meet the target blood pressure [1]. In contrast, in high-income countries, the treatment rate seats at 40% with 25% of patients meeting the blood pressure target [1].

Emphasizing the importance of HTN management, every 10 mmHg reduction in systolic blood pressure level can decrease the risk of future cardiovascular events by up to 25% [2]. A screening program is of great value in identifying HTN at early stages, proposing treatment options and providing support for patients in managing their condition. Treatment options vary based on the degree of HTN progress. At the early stages, dietary and lifestyle changes have shown to be sufficient in controlling HTN. However, as the condition progress and is left untreated, pharmaceutical approach may be warranted to achieve optimal blood pressure control [2–4]. It is estimated that the prevalence of HTN will increase by more than twofold in the Middle East by 2025 [3]. This is a significant concern and calls on the Middle Eastern countries to develop a presentational strategy. Studies on the prevalence, awareness, treatment, and control rate of HTN are needed to set the path for the public health officials in developing these programs. The majority of studies have been conducted on high-income countries, with a handful focused on the Middle East and North Africa (MENA) region. Since there is not systematic review and meta-analysis based on individual and aggregated data to estimate the overall status of hypertension in the MENA region, thus this study aimed to pool data and estimate the long-term prevalence of pre-hypertension (pre-HTN), HTN, awareness, treatment, and control in this region.

Methods

This systematic review and meta-analysis were conducted based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement [4].

Search Strategy

A systematic literature search was conducted in electronic databases, including MEDLINE/ PubMed, Google Scholar, EMBASE, Web of Science, and Scopus, for articles about the prevalence of pre-HTN, HTN, awareness, treatment, and management between databases inception and October 21, 2020. Searches were performed using the terms "pre-HTN," "HTN," "awareness," "treatment," and "control," and other related keywords according to the search strategy of each database (Appendix Table 3). Searched was performed by one investigator, and the results were reviewed by another investigator.

Eligibility Criteria and Selection Study

All cross-sectional studies, in English that investigated the prevalence of pre-HTN, HTN, awareness, treatment, and control rate in adults and older adults (age ≥ 18 years), were

included. All prevalence survey that selected sample participants represented the target population so that the age and sex structure of the sample was consistent with the target population structure for at national or subnational level were included in this study. For multiple publications that used the same source of data, the most recent publication was included. After removing duplicated studies, and removing all self-report studies on the subject, two investigators independently (NM and ES) examined the title, abstract, and full text of related studies, with respect to the eligibility criteria. Probable discrepancies were based on the third expert's opinion (MQ).

Data Extraction Strategy

Two independent investigators performed data extraction with an electronic data extraction form (NM and ES). The following data was extracted: first author, population, study year, sample size, male/female ratio, age (mean or range), HTN definition (cutoff point), level of study, and prevalence/ proportion with 95% confidence interval (CI) for each outcome. Any probable discrepancy was resolved based on the third expert's opinion.

Definition

Awareness, treatment, and control rate of HTN were calculated in the included studies as the proportion of participants with HTN who were aware of their disease, who were treated, and whose HTN was controlled.

Quality Assessment

Quality assessment of included studies was done based on the Newcastle–Ottawa Scale adapted for cross-sectional studies. The scale has seven items and is consisted of selection, comparability, and outcome components. The total score ranged from 0 to 10, with a higher score indicating a lower risk of bias. Quality assessment of studies was categorized as follows: 0 to 4 for "unsatisfactory studies," 5–6 points for "satisfactory studies," 7–8 points for "good studies," and 9–10 points for "very good studies." The quality assessment was conducted independently by two investigators (NM and ES). Probable discrepancies were resolved based on the third expert's opinion (MQ).

Statistical Analysis

Heterogeneity between studies was assessed using Cochran's Q test and I-squared. Due to sever heterogeneity between studies, a random effect model was used to pool prevalence of HTN [5]. A meta-analysis of proportions was used to calculate the pooled prevalence of HTN, awareness,

treatment, and control rates [6]. The subgroup meta-analysis was performed based on gender, study period, level of income, HTN definition, study level (regional, sub-national, national), country, and year. Subgroup analysis, according to the country income level, was done according to the World Bank income classifications [7]. Pooled prevalence, awareness, treatment, and control rates of HTN at country level were estimated for countries with more than 4 studies. Subgroup analysis was categorized into studies conducted from 1990 to 1999, 2000 to 2009, and 2010 to 2020. Sensitivity analysis was performed to estimate the long-term trends in prevalence, awareness, treatment, and control rates of HTN according to standard definition of HTN (definition of HTN as systolic blood pressure of 140 mm Hg or more, or diastolic blood pressure of 90 mm Hg or more, or being on pharmacological treatment). In sensitivity analysis, studies which used other definitions were excluded from analysis. Meta-regression model was fitted to explain the heterogeneity in terms of study-level covariates. STATA 14 (StataCorp, College Station, TX, USA) was used for the analysis.

Results

Search Results

Overall, 2892 studies extracted from the initial search. Upon exclusion of 549 duplicate reviews, the titles, abstracts, and full text of reviews were examined. Totally 178 studies [8–185] met the inclusion criteria. The screening and selection processes of studies are summarized in Fig. 1.

Qualitative Synthesis

The studies were conducted in the 17 MENA countries from 1992 to 2020. Studies comprised of 2,262,797 participants with a mean age of 45.72 ± 8.84 years. Appendix Table 4 shows the general characteristics and the estimated prevalence of pre-HTN and HTN and also awareness, treatment, and control rates of HTN in the included studies. The most included studies were conducted in Iran (107 studies), and the least were conducted in Qatar and Syria (one study). Totally 140 reported prevalence used 140/90 mmHg, 21 used 130/90 mmHg, and 17 used 160/90 mm Hg as the cutoff for the diagnosis of HTN**.** The rate of awareness, treatment, and control of HTN varied among countries. Jordan had the highest awareness rate with 62% (59, 66), and Lebanon had the highest treatment and control rate of HTN with 45% (31, 58) and 27% (16, 38), respectively. Overall rate of HTN awareness ranged from 12 (10–14; Syria) to 69% (63–75; Jordan). Overall rate of HTN treatment ranged from 8 (7–11; Syria) to 78% (75–81; Iran).

Quantitative Synthesis

Sever heterogeneity was noted among the included studies in all subgroups of pre-HTN and HTN prevalence and awareness, treatment, and control rate of HTN (I-squared = 99.95, 99.90, 99.34, 99.46, 99.58%, respectively, $P < 0.001$). Therefore, meta-analysis was performed using random effect model.

Prevalence of Pre-HTN and HTN

The pooled prevalence of pre-HTN and HTN according to gender, population, level of income, HTN definition, and level of studies are illustrated in Table 1. The pooled prevalence of pre-HTN was 33% (95% CI 28, 39). Pre-HTN was more prevalent in males (40%) than females (30%). Pre-HTN was more prevalent in the high-income countries and at national level.

The pooled prevalence of HTN was 26% (25, 27). The highest and lowest pooled prevalence of HTN was in low-middle-income (29%) and high-income countries (24%). The highest prevalence of HTN was reported in studies used the cutoff of 130/90 mm Hg as the definition of HTN. Over the past three decades, the prevalence of hypertension increased significantly in the region (7% increment).

The highest pooled prevalence of HTN in the region was observed in United Arab Emirates with 36% (28–43). Over the three past decades, prevalence of HTN in Iran increased from 22 (1990–2000) to 26% (2010–2020).

HTN Awareness, Treatment, and Control Rates

The pooled awareness, treatment, and control rates of HTN according to gender, population, level of income, HTN definition, and level of studies are illustrated in Table 2. By random effect model, the pooled awareness, treatment, and control rates were 50% (48, 53), 41% (38, 44), and 19% (17, 21), receptively. The pooled awareness, treatment, and control rates were lower significantly in men than women. While the highest awareness of HTN was in upper-middle-income countries with 52% (49, 55), high-income countries had highest rate of treatment and control of HTN with 43% (33, 53) and 25% (17, 33), respectively. The pooled awareness, treatment, and control rates of HTN in studies that used cutoff 160/90 mm Hg for definition were higher in comparison to other definitions. Based on study level, the highest awareness, treatment, and control rates of HTN were at subnational level.

The highest pooled awareness rate of HTN was observed in Jordan (61%), and in all other countries, the awareness rate was approximately 50%. The pooled treatment rates of HTN ranged 40–47% at country level in the region. The highest and lowest pooled control rates of HTN were observed in Lebanon and Turkey, respectively (Appendix Table 5).
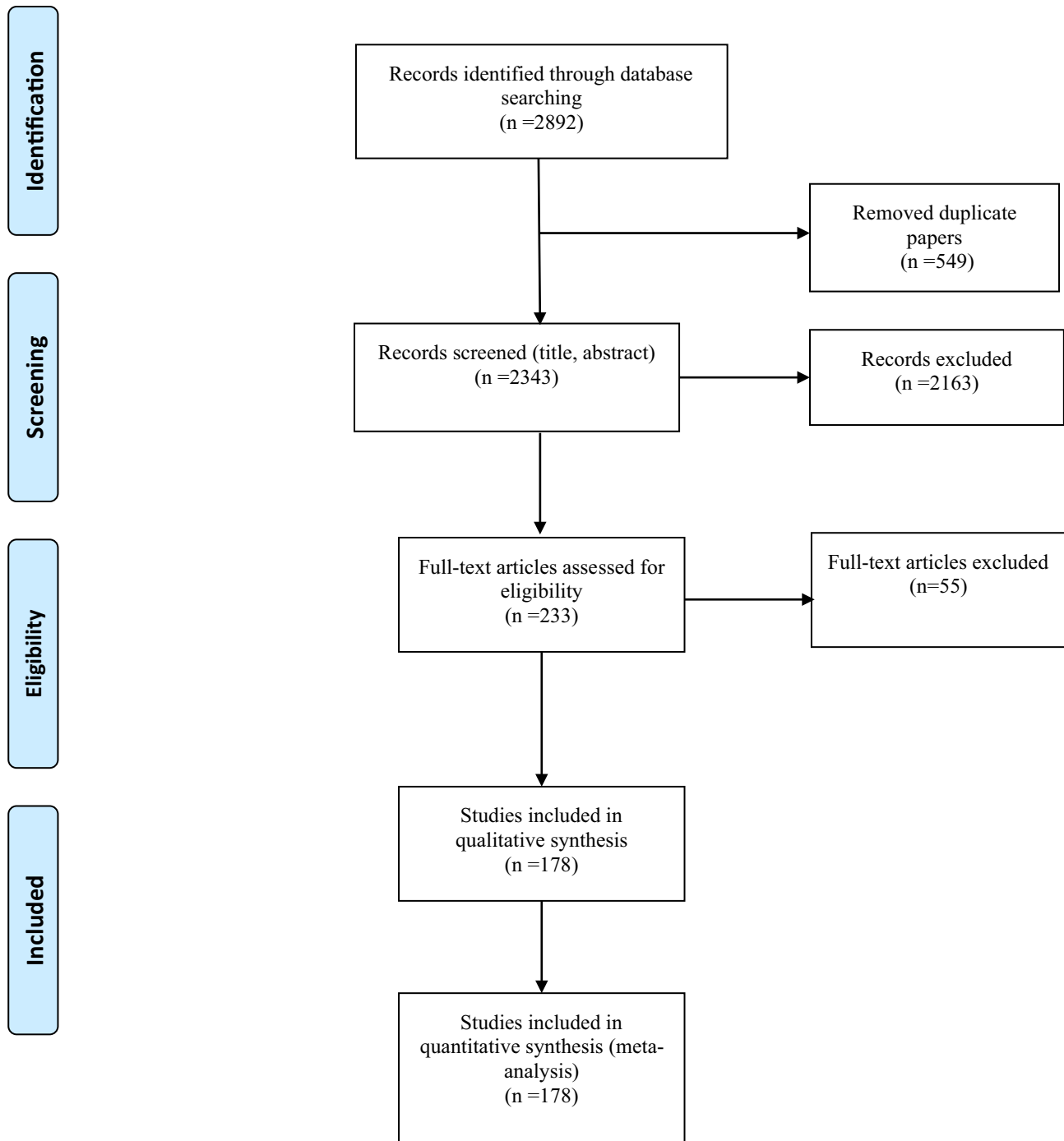
Fig. 1 Studies search and review flowchart

Sensitivity Analysis

Sensitivity analysis according to definition of HTN for pooled prevalence of HTN, awareness, treatment, and control rates is presented in Fig. 2. As it shows in the forest plot (Fig. 3), the pooled prevalence of HTN, awareness, treatment, and control rates did not change significantly according to HTN cutoff point > 140/90 mmHg compare to all definitions. According to standard definition of HTN (> 140/90 mm Hg), over the past three decades, the prevalence of hypertension increased linearly in the region. Although over the past three decades, the pooled awareness and treatment rates of HTN did not change significantly, the pooled control rate improved significantly in the region (approximately 10% improvement in the two recent decades) (Fig. 2).

Table 1 Pooled prevalence of pre-hypertension and hypertension according to gender, study period, income, definition, and level of study using random effect meta-analysis model in the MENA region

	Pooled prevalence (95% CI)	
	Pre-hypertension	Hypertension
Overall	33 (28–39)	26 (25–27)
Gender		
Male	40 (29–51)	29 (26–32)
Female	30 (22–37)	30 (28–33)
Both sexes	32 (24–41)	24 (23–25)
Study period		
1990–1999	-	21 (18–24)
2000–2009	31 (24–39)	25 (23–27)
2010–2020	34 (28–41)	28 (26–30)
Income level		
High income (30)	50 (41–58)	24 (21–26)
Upper middle income	32(25–38)	26 (24–27)
Lower middle income	(-)	29 (23–36)
Low income	(-)	27 (22–32)
Definition of HTN, mm Hg		
130/90	(-)	30 (27–33)
140/90	(-)	25 (24–27)
160/90	(-)	20 (16–24)
Study level		
Sub-national	31 (26–37)	24 (23–26)
Regional	(-)	30 (25–35)
National	42 (37–47)	26 (24–28)

Table 2 Pooled awareness, treatment and control rate of hypertension according to gender, study period, study population, income level, definition, and level of study using random effect meta-analysis model in the MENA region

	Pooled rate (95% CI)		
	Awareness	Treatment	Control
Overall	50 (48–53)	41 (38–44)	19 (17–21)
Gender			
Male	45 (39–50)	34 (28–40)	15 (10–19)
Female	61 (55–68)	48 (40–56)	19 (13–24)
Both sexes	49 (46–52)	41 (38–45)	21 (18–23)
Study period			
1990–1999	54 (45–63)	51 (43–59)	18(13–23)
2000–2009	42 (38–46)	34(30–38)	12 (9–16)
2010–2020	52 (49–56)	41 (38–44)	23 (20–26)
Income level			
High income	46 (37–55)	43 (33–53)	25 (17–33)
Upper middle income	52 (49–55)	43 (38–47)	20 (18–22)
Lower middle income (32)	37 (35–40)	28 (26–30)	10 (9–11)
Low income (32)	40 (16–65)	29 (10–49)	10 (8–12)
Definition of HTN, mm Hg			
130/90	51 (42–61)	47 (38–56)	28 (22–34)
140/90	47 (44–50)	37 (34–41)	17 (14–20)
160/90	52 (30–74)	62 (49–75)	35 (7–62)
Study level			
Subnational	51 (46–56)	45 (37–53)	22 (17–28)
Regional	43 (8–78)	39 (1–78)	22 (8–36)
National	47 (44–50)	39 (34–43)	21 (17–24)

Meta-regression

The results of meta-regression showed that heterogeneity among the included studies explained by level of income and level of study for pre-HTN, by mean age of study population, country, level of study for the prevalence of HTN, by mean age of study population and definition for awareness and treatment rate, and by mean age of study population, definition, and level of study for control rate (Appendix Table 6).
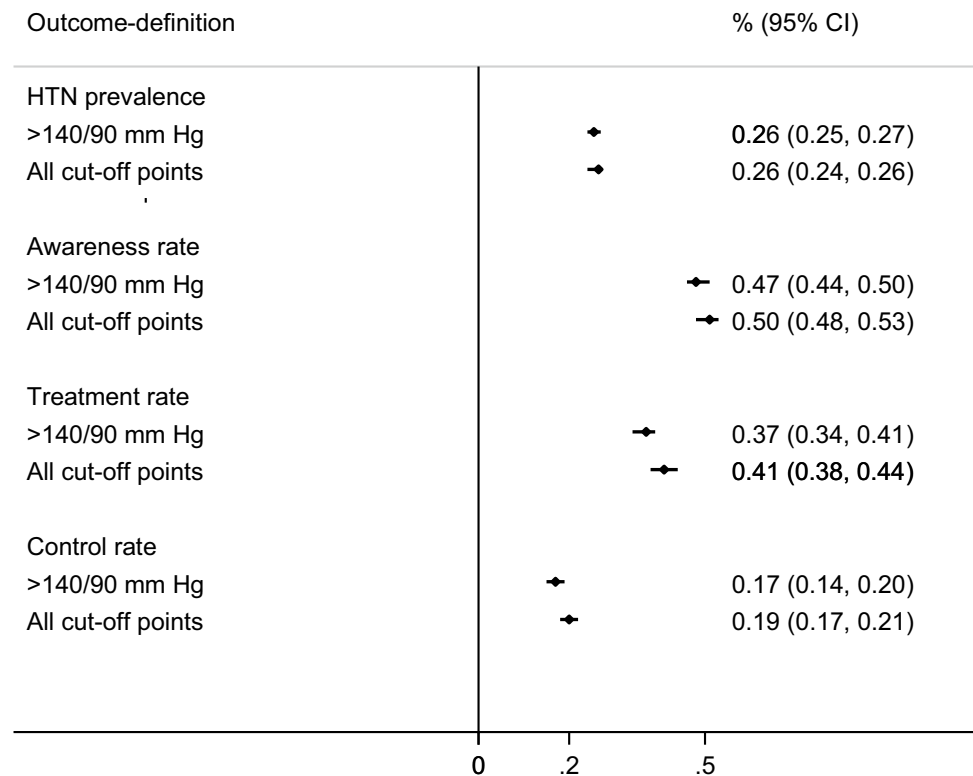
Discussion

In the present comprehensive systematic review and meta-analysis study on the prevalence of HTN and its management in 17 MENA countries between 1992 and 2020, the pooled prevalence of pre-HTN and HTN was estimated to be 33% and 26%, respectively. In this regard, the results of a large population-based cohort of Chinese, Malay, and Indian populations showed the HTN prevalence of 31.1% [186]. In a multinational cross-sectional study from six Latin American countries, HTN prevalence was reported as 44%, which is significantly higher than the prevalence rate in the MENA countries [187]. The global prevalence of pre-HTN and HTN in adults has been estimated at 36% and 31%, respectively, in the systematic analyses of population-based studies [188, 189], which is above the MENA countries. Healthcare infrastructure for HTN screening, access to health services, as well as social and economic status could account for this discrepancy.

Pre-HTN was more common in males and high-income countries, while HTN was more prevalent in low-middle-income countries. It seems that there is a relationship between the prevalence of pre-HTN and HTN and the socioeconomic status (SES). Results of a meta-analysis confirmed an association between low SES and high blood pressure [190]. However, another opinion is that in developed countries, lower SES is associated with a higher prevalence of HTN. In contrast, in developing countries, higher SES is accompanied by higher HTN prevalence due to higher sodium and alcohol intakes and a higher prevalence of obesity [191].

Moreover, the prevalence of HTN in male and female was not statistically different. This finding is inconsistent with previous studies [153, 192]. To the extent of that in a multi-ethnic cross-sectional survey in the Asian population, age

Fig. 2 Forest plot of pooled prevalence, awareness, treatment, and control rate of hypertension according to definition of hypertension in the MENA region

Outcome-definition		% (95% CI)
HTN prevalence		
>140/90 mm Hg		0.26 (0.25, 0.27)
All cut-off points		0.26 (0.24, 0.26)
Awareness rate		
>140/90 mm Hg		0.47 (0.44, 0.50)
All cut-off points		0.50 (0.48, 0.53)
Treatment rate		
>140/90 mm Hg		0.37 (0.34, 0.41)
All cut-off points		0.41 (0.38, 0.44)
Control rate		
>140/90 mm Hg		0.17 (0.14, 0.20)
All cut-off points		0.19 (0.17, 0.21)

and education have been consistently associated with HTN across all ethnic groups [186].

This systematic review showed that the prevalence of pre-HTN and HTN varied widely in different countries. Early detection of pre-HTN is essential to prevent the development of HTN through cost-effective dietary programs, lifestyle modifications, and regular blood pressure measurements. Reducing tobacco, alcohol and sodium intake, as well as increasing physical activity and consumption of fruits and vegetables are worth considering as a primary prevention method for HTN [193].

Our findings showed that the prevalence HTN increased significantly in the region (7% increment). In contrast, an analysis of nationally representative surveys of high-income countries reported no noticeable change in HTN prevalence from 1976 to 2017, with some age and sex groups showing a decline or increment in prevalence rate [194]. It seems that strategies such as developing evidence-based guidelines for healthcare providers and implementing regular blood pressure measurements have been useful in controlling HTN [194].
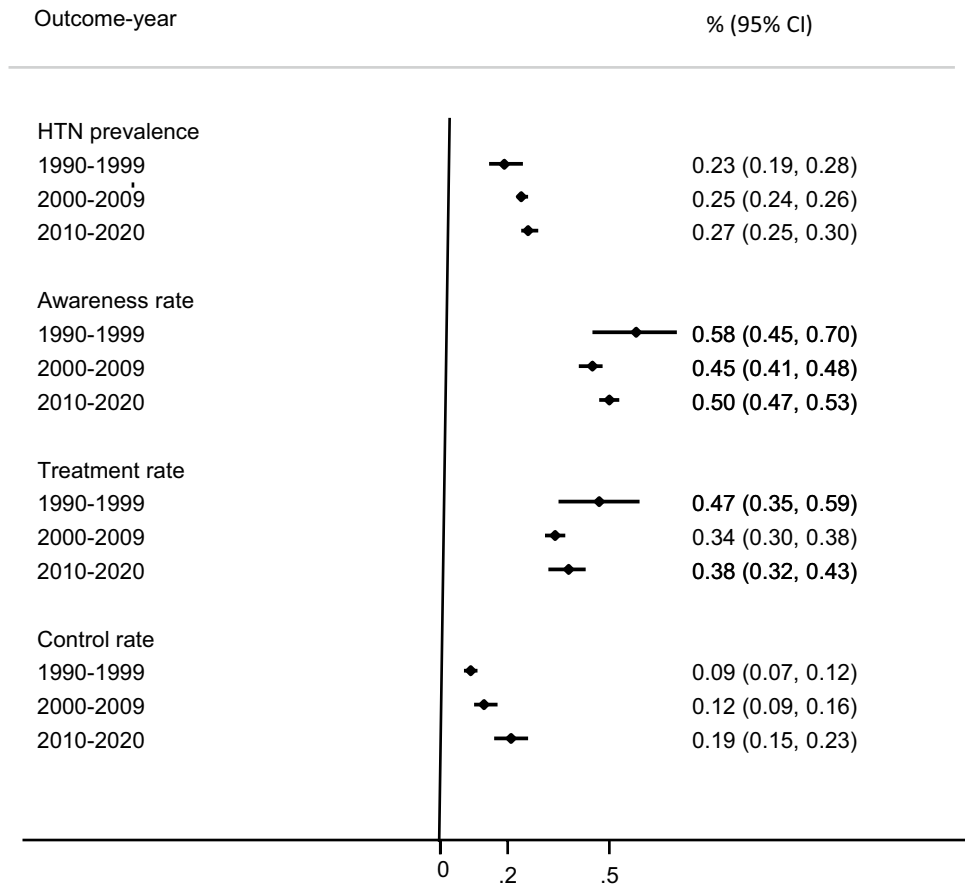
The overall awareness, treatment, and control rates of HTN in the MENA countries were estimated at 50%, 41%, and 19%, respectively. About half of the patients with HTN in the MENA were aware of their disease; however, only one-fifth of the patients have managed to control their blood pressure. While in Africa, the treatment and control rate was reported at 59.9% and 24.6%, respectively [195], and the treatment rate reached 82% in Canada [196]. In a multinational population-based study, 46.5% of participants with HTN were aware of their disease, with a controlled rate of 32.5%, which is higher than the MENA [168]. The observed differences in HTN awareness and treatment among countries may be attributable to variations in lifestyle and cultural factors [197, 198].

During the past two decades, the pooled control rate of HTN improved significantly in the region (approximately 10% improvement in the two recent decades). Analysis of 12 high-income countries' national surveys revealed improvement in HTN awareness, treatment, and control since the 1980s and 1990s. However, the control rates have been plateaued during the past decade in these countries [194].

The low control rate of HTN and the gap between detection and treatment of HTN could be attributed to the high cost of anti-hypertensive agents, poor access to physicians and healthcare facilities, and plow perceptions of the benefit of adherence to medications. Therefore, based on the results of previous experiences, the use of polypill as a combination therapy and initial treatment with non-physician healthcare workers could be reasonable strategies for the prevention and control of HTN in low- and middle-income countries [199].

Fig. 3 Forest plot of pooled prevalence, awareness, treatment and control rates of hypertension according to definition of hypertension more than 140/90 mmHg by study period in the MENA region

Outcome-year	% (95% CI)
HTN prevalence	
1990-1999	0.23 (0.19, 0.28)
2000-2009	0.25 (0.24, 0.26)
2010-2020	0.27 (0.25, 0.30)
Awareness rate	
1990-1999	0.58 (0.45, 0.70)
2000-2009	0.45 (0.41, 0.48)
2010-2020	0.50 (0.47, 0.53)
Treatment rate	
1990-1999	0.47 (0.35, 0.59)
2000-2009	0.34 (0.30, 0.38)
2010-2020	0.38 (0.32, 0.43)
Control rate	
1990-1999	0.09 (0.07, 0.12)
2000-2009	0.12 (0.09, 0.16)
2010-2020	0.19 (0.15, 0.23)

Regarding the awareness, treatment, and control of HTN, the women and high-income countries had a higher rate. In agreement with similar studies conducted on the Asian population [186], men were more likely to be left undetected and untreated than women. Moreover, in high SES countries, the awareness and control of HTN are generally better because of high access to healthcare services and higher literacy levels [168, 186, 200, 201].

The rate of awareness, treatment, and control of HTN could be translated to the overall healthcare system performance at the national level. In the present study, although the prevalence of HTN in Iran has increased over the past two decades, the level of awareness, treatment, and control of HTN has slightly improved. In a meta-analysis that was conducted on 417,392 Iranian adults, the prevalence of HTN was estimated at 20%, which is comparable to the findings of this review [192].

There has been no other comparative study of long-term trends in HTN prevalence, awareness, treatment, and control in the MENA. The meta-analysis approach with comprehensively investigating databases in the longest possible time to determine the prevalence of HTN was the advantage of this study. One of the limitations of the present study is that some studies did not include prevalence information by gender

and other categories. Another limitation was the unequal number of studies in different countries. Moreover, methodological differences between included studies and over time caused high heterogeneity among studies should not be overlooked completely, although we performed subgroup and metaregression analysis. Also, the quality score of some of the included individual studies was low, which could have affected our results.

Conclusion

The result of this study showed that HTN is a significant public health problem in the MENA countries. About half the patients with HTN are unaware of their medical condition. Although the diagnosed patients receive relatively good treatment, the condition is controlled only in a small number of patients. The present study provides a great tool for public health authorities in the MENA to understand the status of screening, prevention, and treatment in their countries. Implementing clinical guidelines with simplified recommendations, alongside regular screening, and physician consultation could provide a major benefit in managing HTN.

Appendix

Table 3 Search strategy

PubMed

(((((((("Hypertension"[235]) OR "Blood Pressure"[235]) OR ((((((("systolic pressure"[Title/Abstract]) OR "diastolic pressure"[Title/Abstract]) OR "pulse pressure"[Title/Abstract]) OR hypertensive*[Title/Abstract]) OR "pre-hypertension"[Title/Abstract]) OR prehypertension[Title/Abstract]))) AND (("Awareness"[235]) OR awareness[Title/Abstract])) AND Humans[235]))

((((("Hypertension"[235]) OR "Blood Pressure"[235]) OR ((((((("systolic pressure"[Title/Abstract]) OR "diastolic pressure"[Title/Abstract]) OR "pulse pressure"[Title/Abstract]) OR hypertensive*[Title/Abstract]) OR "pre-hypertension"[Title/Abstract]) OR prehypertension[Title/Abstract]))) AND (((((((Therapy[Title/Abstract]) OR treatment[Title/Abstract]) OR control[Title/Abstract]) OR ("Therapeutics"[235] AND Humans[235]))

Scopus

(((TITLE-ABS-KEY (hypertension) OR TITLE-ABS-KEY (*"Blood Pressure"*) OR TITLE-ABS-KEY (*"systolic pressure"*) OR TITLE-ABS-KEY (*"diastolic pressure"*) OR TITLE-ABS-KEY (*"pulse pressure"*) OR TITLE-ABS-KEY (hypertensive*) OR TITLE-ABS-KEY (*"pre-hypertension"*) OR TITLE-ABS-KEY (prehypertension) OR TITLE-ABS-KEY (*"HTN"*) OR TITLE-ABS-KEY (*"SBP"*) OR TITLE-ABS-KEY (*"DBP"*)) AND ((TITLE-ABS-KEY (awareness) OR TITLE-ABS-KEY (aware*))))

(((TITLE-ABS-KEY (hypertension) OR TITLE-ABS-KEY (*"Blood Pressure"*) OR TITLE-ABS-KEY (*"systolic pressure"*) OR TITLE-ABS-KEY (*"diastolic pressure"*) OR TITLE-ABS-KEY (*"pulse pressure"*) OR TITLE-ABS-KEY (hypertensive*) OR TITLE-ABS-KEY (*"pre-hypertension"*) OR TITLE-ABS-KEY (prehypertension) OR TITLE-ABS-KEY (*"HTN"*) OR TITLE-ABS-KEY (*"SBP"*) OR TITLE-ABS-KEY (*"DBP"*)) AND ((TITLE-ABS-KEY (treatment) OR TITLE-ABS-KEY (control) OR TITLE-ABS-KEY (treat*) OR TITLE-ABS-KEY (therapy))))

ISI/WOS

TOPIC: (hypertension) OR TOPIC: ("Blood Pressure") OR TOPIC: ("systolic pressure") OR TOPIC: ("diastolic pressure") OR TOPIC: ("pulse pressure") ORTOPIC: (hypertensive*) OR TOPIC: ("pre-hypertension") OR TOPIC: (prehypertension) OR TOPIC: ("HTN") OR TOPIC: ("SBP") OR TOPIC: ("DBP")

Indexes = SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years

TOPIC: (awareness)

Indexes = SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years

TOPIC: (hypertension) OR TOPIC: ("Blood Pressure") OR TOPIC: ("systolic pressure") OR TOPIC: ("diastolic pressure") OR TOPIC: ("pulse-pressure") ORTOPIC: (hypertensive*) OR TOPIC: ("prehypertension") OR TOPI: (prehypertension) OR TOPIC: ("HTN") OR TOPIC: ("SBP") OR TOPIC: ("DBP") Indexes = SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years TOPIC: (tratment) OR TOPIC: (control) OR TOPIC: (therapy) OR TOPIC: (treat*) Indexes = SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years

[#]The geographical domains for searches were set on Bahrain, Cyprus, Egypt, Iraq, Iran, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen, and Middle East

Table 4 Characteristic of included article

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
Algeria	Hamida F/2013 [8]	722	NR	58.5	140/90	Subnational	NR	50.2 (46.5, 53.99)	NR	NR	NR	5
	Benkheddaet/2005 [9]	1478.00	0.64	44.2	140/90	National	NR	35.3 (32.9–37.8)	NR	NR	NR	10
	Latifa Bh/2007 [10]	2308	NR	54.5	140/90	Subnational	NR	32.7 (28.78, 36.57)	NR	NR	NR	5
	Temmaretal/2007 [11]	1346.00	0.89	55	140/90	Regional	NR	44 (41.3–46.7)	NR	NR	NR	5
Egypt	El-Zanaty F/2009 [12]	3342.00	NR	45.6	140/90	National	NR	11.7 (11.1–12.3)	NR	54.1 (52, 56.2)	39.5 (34.6, 44.7)	7
	Ibrahim M/1995 [13]	6733.00	NR	NR	140/90	National	NR	26.3 (25.3–27.4)	37.5 (35.2, 39.8)	23.9 (21.9, 25.9)	8 (6.8, 9.4)	9
Iran	Mohamed Mr/2000 [14]	1927	NR	42.5	140/90	Subnational	NR	27.9 (26–30)	NR	NR	NR	6
	Akbar-Zadeh F/2003 [15]	2400.00	NR	NR	140/90	Subnational	NR	16.29 (12.71–19.88)	NR	NR	NR	5
	Amiri M/2000 [16]	1854.00	NR	NR	140/90	Subnational	NR	22.1 (18.18–26.01)	NR	NR	NR	6
	Fakhrzadeh H/1998 [17]	1036.00	NR	NR	160/90	Subnational	NR	16.94 (11.64–22.24)	NR	NR	NR	6
	Fakhrzadeh H/2001 [18]	2180.00	NR	NR	140/90	Subnational	NR	22.1 (18.47–25.72)	NR	NR	NR	6
	Latifi Sm/2000 [19]	2900.00	NR	NR	140/90	Subnational	NR	26.84 (23.78–29.9)	NR	NR	NR	6
	Mostafavi H/2004 [20]	4045.00	NR	NR	140/90	Subnational	NR	25.71 (23.09–28.34)	NR	NR	NR	6
	Mostafavi H/2000 [21]	2496.00	NR	NR	140/90	Subnational	NR	22.15 (18.75–25.54)	NR	NR	NR	6
	Navaei L/1998 [22]	1919.00	NR	NR	140/90	Subnational	NR	33.23 (29.66–36.79)	NR	NR	NR	6
	Navaii L/2000 [23]	8647.00	NR	NR	140/90	Subnational	NR	21.7 (19.85–23.56)	NR	NR	NR	6
	Shahbazpour N./2003 [24]	1000.00	NR	NR	140/90	Subnational	NR	20.65 (15.38–25.91)	NR	NR	NR	6
	Abdollahi/2007 [25]	5000.00	NR	NR	140/90	Subnational	NR	31 (29.71–32.28)	NR	NR	NR	5
	Abtahi/2011 [26]	3115.00	NR	NR	140/90	Subnational	42.6 NR	18.2 (16.84–19.55)	NR	NR	NR	5
	Aghaei M/2014 [27]	3049.00	0.81	42.39 ± 14.01	140/90	Subnational	47.3 (45.5–49.1)	26.9 (25.3–28.5)	NR	NR	NR	10

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age±SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Aghasadeghi/2008 [28]	216.00	NR	NR	140/90	Subnational	NR	37.4 (31.31–44.13)	NR	NR	NR	5
	Agheli/2006 [29]	9752.00	NR	NR	140/90	National	32.4 (31.5–33.3)	26 (25.2–26.9)	NR	NR	NR	7
	Ahmadi A/2000 [30]	109	NR	NR	140/90	Subnational	NR	21.31 (9.24–33.38)	NR	NR	NR	5
	Alikhani/2009 [31]	70,981.00	NR	NR	140/90	National	NR	23.8 (23.48–24.11)	NR	NR	NR	6
	Amiri/2004 [32]	2092.00	NR	NR	140/90	Subnational	NR	24.5 (22.65–26.34)	NR	NR	NR	6
	Amiri Z/2015 [33]	1953.00	NR	NR	140/90	Subnational	NR	25.9 (24–27.9)	NR	NR	NR	7
	Amirkhizi/2008 [34]	370.00	NR	NR	140/90	Subnational	NR	14.3 (10.73–17.86)	NR	NR	NR	5
	Arefi S/1996 [35]	10,180.00	1.96	NR	160/90	Subnational	NR	17.7 (17–18.5)	NR	NR	NR	9
	Asgari.S/2019 [36]	10,576.00	0.99	NR	130/90	Subnational	NR	51.6 (50.7–52.6)	NR	28.7 (27.7–30.1)	NR	9
	Azimi/2010 [37]	4519.00	1.05	NR	140/90	Subnational	40.56 (39.13–41.99)	24.18 (22.93–25.43)	NR	NR	NR	
	Azizi F/2004 [38]	6899.00	NR	NR	140/90	Subnational	NR	19.05 (16.94–21.15)	NR	NR	NR	6
	Azizi F/2001 [39]	1766.00	NR	NR	140/90	Subnational	NR	46.06 (42.73–49.39)	NR	NR	NR	6
	Azizi A/2008 [40]	4718.00	0.76	NR	140/90	Subnational	15.8 (14.8–16.9)	14.3 (13.3–15.3)	NR	NR	NR	8
	Azizi F/2003 [41]	11,800.00	NR	NR	140/90	Subnational	NR	22.9 (22.14–23.65)	NR	NR	NR	7
	Azizi F/2002 [42]	8491.00	NR	NR	140/90	Subnational	NR	21.6 (20.8–22.5)	NR	NR	NR	6
	Badakhsh M/2015 [43]	2036.00	1.38	53.4±12.86	140/90	Subnational	29.9 (27.9–31.9)	35.7 (33.6–37.8)	NR	NR	NR	8
	Barikani/2010 [44]	328.00	NR	NR	140/90	Subnational	NR	27.2 (22.38–32.01)	NR	NR	NR	5
	Baroogh/2010 [45]	450.00	NR	NR	140/90	Subnational	NR	15.8 (12.43–19.16)	NR	NR	NR	5
	Behforooz Mr/2002 [46]	1000.00	NR	NR	140/90	Subnational	NR	25.84 (20.74–30.93)	NR	NR	NR	5

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Boskabadi/2006 [47]	704.00	NR	NR	140/90	Subnational	NR	20.9 (17.89–23.90)	NR	NR	NR	5
	Chaman R/2008 [48]	1500.00	0.92	NR	140/90	Subnational	NR	18.4 (16.5–20.5)	NR	NR	NR	9
	Dabghmanesh, Mh/2000 [49]	3245.00	0.67	NR	140/90	Subnational	NR	27.5(95% CI, NR)	NR	NR	NR	8
	Delavari/2007 [50]	48,961.00	1.00	NR	140/90	National	NR	30.5 (30.1–30.9)	36.8 (36–37.6)	33.1 (32.4–33.9)	8.1 (7.7–8.5)	6
	Delavari/2007 [50]	26,171.00	0.99	NR	140/90	National	NR	29.2 (28.6–29.8)	32 (31–33.1)	28.2 (27.2–29.2)	6.2 (5.7–6.8)	8
	Delavari/2007 [50]	75,112.00	NR	NR	140/90	National	NR	30.2 (29.87–30.52)	NR	NR	NR	8
	Delavari Ar/2005 [50]	24,525.00	NR	NR	140/90	National	NR	16.2 (15.7–16.6)	33.4 (32.8–34)	21.9 (21–22.8)	8.5 (7.9–9.1)	7
	Delpishe A/2000 [51]	342.00	NR	NR	140/90	Subnational	NR	38.76 (31.46–46.06)	NR	NR	NR	5
	Ebrahimi M/2010 [52]	30,000.00	NR	NR	140/90	National	NR	17.4 (16.9–18.34)	41.89 (40.72–43.06)	33.35 (32.23–34.48)	35.1 (33.13–37.07)	7
	Ebrahimi M/2016 [53]	9762.00	0.67	48.7 ± 8.16	140/90	Subnational	12 (11.4–12.7)	23 (22.9–23.9)	45 (44.01–45.99)	NR	NR	8
	Eghbali M/2018 [54]	2107.00	NR	39.53 ± 15.74	130/90	Subnational	NR	17.3 (15.7–19)	69.2 (64.2–73.9)	63.5 (58.3–68.4)	41.5 (36.4–46.7)	7
	Esteghamati/2016 [55]	8218.00	NR	NR	140/90	National	NR	25.6 (24.65–26.54)	NR	NR	NR	6
	Esteghamati/2009 [56]	5287.00	NR	NR	140/90	National	NR	26.6 (25.40–27.79)	NR	NR	NR	6
	Esteghamati A/2008 [57]	68,250.00	NR	40	140/90	National	43.6 (43.3–44)	31.6 (31.2–31.9)	33.9 (33.3–34.5)	24.8 (24.3–25.4)	6 (5.7–6.3)	8
	Esteghamati A/2009 [56]	4233.00	1.00	NR	140/90	National	38.2 (36.1–40.2)	26.6 (24.4–28.9)	NR	NR	NR	9
	Fakhrzadeh H/2000 [58]	1235.00	NR	NR	140/90	Subnational	NR	23.24 (18.58–27.91)	NR	NR	NR	6
	Fakhrzadeh H/2004 [59]	1573.00	0.64	NR	140/90	Subnational	NR	28.5 (26.3–30.8)	NR	NR	NR	9
	Fakhrzadeh H/2008 [1]	846.00	NR	NR	140/90	Subnational	NR	26.9 (26–27.8)	NR	NR	NR	6
	Farzadfar/2012 [60]	65,619.00	1.00	NR	140/90	National	NR	18.0 (17.9–18.1)	49.2 (48.3–50)	35.7 (34.9–36.5)	NR	6

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Fattahi E/2000 [61]	2400.00	NR	NR	140/90	Subnational	NR	21.36 (17.88–24.84)	NR	NR	NR	10
	Gandomkar A/2018 [62]	9264.00	0.86	52.6	130/90	Subnational	NR	26.9 (26–27.8)	49.6 (47.6–51.6)	56 (54–58)	38.4 (36.5–40.4)	6
	Ghanbarian A,/2003 [63]	423.00	NR	NR	140/90	Subnational	NR	30.6 (23.46–37.75)	NR	NR	NR	6
	Ghari Poor/2012 [64]	975.00	NR	NR	140/90	Subnational	NR	18.9 (16.44–21.35)	NR	NR	NR	6
	Ghazanfari/2010 [65]	400.00	NR	NR	140/90	Subnational	NR	23.8 (19.62–27.97)	NR	NR	NR	5
	Faramarzi/2011 [66]	447,251.00	1.17	NR	140/90	Subnational	NR	21.1 (21–21.2)	NR	NR	NR	5
	Ghorbani Z/2018 [67]	1038.00	NR	NR	130/90	Subnational	NR	29.88 (27.09–32.75)	62.26(56.6–67.68)	83.87 (79.29–87.79)	68.39 (62.89–73.53)	7
	Goodarzei M.R/2005 [68]	1530.00	0.82	NR	140/90	Subnational	NR	13.9 (12.2–15.8)	NR	NR	NR	9
	Hadaegh F/2015 [69]	3597.00	0.69	NR	140/90	Subnational	40 (38.4–41.7)	NR	NR	NR	NR	9
	Hekmatpoor/1998 [70]	2000.00	NR	NR	140/90	Subnational	NR	9.6 (8.30–10.89)	NR	NR	NR	6
	IHPS, Ministry of Health/1999 [71]	1075.00	NR	NR	140/90	Subnational	NR	12.51 (7.75–17.27)	NR	NR	NR	6
	IHPS, Ministry of Health/1999 [71]	69,489.00	NR	NR	140/90	National	NR	12.54 (10.64–14.43)	NR	NR	NR	5
	IHPS, Ministry of Health/1999 [71]	11,054.00	NR	NR	140/90	Subnational	NR	13.08 (11.37–14.79)	NR	NR	NR	5
	IHPS, Ministry of Health/1999 [71]	5812.00	NR	NR	140/90	Subnational	NR	11.29 (8.95–13.63)	NR	NR	NR	6
	IHPS, Ministry of Health/1999 [71]	3776.00	NR	NR	140/90	Subnational	NR	11.52 (8.67–14.37)	NR	NR	NR	6
	IHPS, Ministry of Health/1999 [71]	3740.00	NR	NR	140/90	Subnational	NR	9.02 (6.12–11.92)	NR	NR	NR	6
	IHPS, Ministry of Health/1999 [71]	3600.00	NR	NR	140/90	Subnational	NR	9.13 (6.17–12.08)	NR	NR	NR	5
	IHPS, Ministry of Health/1999 [71]	3441.00	NR	NR	140/90	Subnational	NR	24.07 (21.32–26.82)	NR	NR	NR	6
	IHPS, Ministry of Health/1999 [71]	2586.00	NR	NR	140/90	Subnational	NR	9.69 (6.29–13.09)	NR	NR	NR	6

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	IHPS. Ministry of Health/1999 [71]	2236.00	NR	NR	140/90	Subnational	NR	14.7 (11.18–18.21)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	2132.00	NR	NR	140/90	Subnational	NR	11.1 (7.43–14.76)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1914.00	NR	NR	140/90	Subnational	NR	21.27 (17.67–24.88)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1760.00	NR	NR	140/90	Subnational	NR	17.97 (14.16–21.78)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1692.00	NR	NR	140/90	Subnational	NR	11.84 (7.3–16.38)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1456.00	NR	NR	140/90	Subnational	NR	10.9 (6.61–15.18)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1450.00	NR	NR	140/90	Subnational	NR	9.61 (5.29–13.93)	NR	NR	NR	5
	IHPS. Ministry of Health/1999 [71]	1255.00	NR	NR	140/90	Subnational	NR	11.87 (7.86–15.88)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1214.00	NR	NR	140/90	Subnational	NR	10.17 (5.56–14.78)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1173.00	NR	NR	140/90	Subnational	NR	8.84 (4.84–12.85)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1142.00	NR	NR	140/90	Subnational	NR	17.25 (12.73–21.78)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	1003.00	NR	NR	140/90	Subnational	NR	11.33 (6.42–16.24)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	986.00	NR	NR	140/90	Subnational	NR	11.27 (6.32–16.21)	NR	NR	NR	5
	IHPS. Ministry of Health/1999 [71]	936.00	NR	NR	140/90	Subnational	NR	14.87 (9.94–19,8)	NR	NR	NR	5
	IHPS. Ministry of Health/1999 [71]	935.00	NR	NR	140/90	Subnational	NR	11.63 (6.58–16.68)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	922.00	NR	NR	140/90	Subnational	NR	17.28 (12.43–22.14)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	897.00	NR	NR	140/90	Subnational	NR	9.19 (4.03–14.36)	NR	NR	NR	6
	IHPS. Ministry of Health/1999 [71]	880.00	NR	NR	140/90	Subnational	NR	10.19 (5.02–15.36)	NR	NR	NR	5
	IHPS. Ministry of Health/1999 [71]	810.00	NR	NR	140/90	Subnational	NR	9.06 (3.71–14.41)	NR	NR	NR	5

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	IHPS. Ministry of Health/1999 [71]	651.00	NR	NR	140/90	Subnational	NR	10.32 (4.63–16.02)	NR	NR	NR	6
	Jahromi/2017 [72]	263.00	NR	NR	140/90	Subnational	NR	15.1 (10.77–19.42)	NR	NR	NR	4
	Janghorbani M/2008 [73]	69,722.00	1.01	44.1	140/90	National	52.1 (51.7–52.5)	23.4 (23.1–23.7)	NR	NR	NR	9
	Javadi/2008 [74]	1000.00	NR	NR	140/90	Subnational	NR	22.4 (19.81–24.98)	NR	NR	NR	6
	Javadi/2009 [75]	400.00	NR	NR	140/90	Subnational	NR	6.5 (4.08–8.91)	NR	NR	NR	6
	Javadi Hr 1999/2000 [76]	5917.00	NR	NR	140/90	Subnational	NR	7.21 (4.77–9.64)	NR	NR	NR	5
	Kalani Z/2009 [77]	1130.00	0.68	NR	140/90	Subnational	NR	38.1 (35.3–41)	38.1 (33.4–42.8)	77 (72.8–80.9)	12.3 (9.3–15.8)	8
	Kassaei/2010 [78]	1000.00	NR	NR	140/90	Subnational	NR	27.8 (25.02–30.57)	NR	NR	NR	6
	Katibeh M/2019 [79]	2098.00	0.90	54.1±10	130/90	Subnational	33.2 (31.2–35.3)	55.8 (53.6–57.9)	64 (61.2–66.8)	NR	16.1 (14–18.3)	8
	Kazemi T/2017 [80]	1286.00	0.95	NR	140/90	Subnational	NR	20.1 (17.9–22.4)	NR	NR	NR	8
	Kazemi T/2018 [81]	1280.00	NR	NR	130/90	Subnational	21.4 (19.2–23.7)	NR	NR	NR	NR	6
	Kelishadi R/2008 [82]	3694.00	NR	NR	140/90	Subnational	NR	18.7 (17.5–20)	NR	NR	NR	7
	Khadirsharbiani/2001 [83]	1050.00	NR	NR	140/90	Subnational	NR	20.7 (18.24–23.15)	NR	NR	NR	6
	Khajedaluee M/2016 [84]	2974.00	0.54	NR	130/90	Subnational	NR	22.1 (20.6–23.6)	NR	NR	NR	9
	Khani M/2000 [85]	1500.00	NR	NR	140/90	Subnational	NR	12.3 (10.63–13.96)	NR	NR	NR	6
	Khosravi/1994 [86]	6000.00	NR	NR	140/90	Subnational	NR	31.2 (30.02–32.37)	NR	NR	NR	6
	Khosravi/2001 [86]	8104.00	NR	NR	140/90	Subnational	NR	17.5 (16.67–18.32)	NR	NR	NR	6
	Khosravi/1998 [86]	6781.00	NR	NR	140/90	Subnational	NR	22.8 (21.80–23.79)	NR	NR	NR	6
	Khosravi/2009 [86]	4853.00	NR	NR	140/90	Subnational	NR	17.9 (16.82–18.97)	NR	NR	NR	9

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Malekzadeh M/2013 [87]	50,045.00	NR	NR	140/90	Subnational	NR	42.7 (42.2–43.1)	46.2 (45.6–46.9)	17.6 (17.1–18.1)	5.6 (5.3–6)	8
	Maracy M/2012 [88]	3000.00	1.02	NR	140/90	Subnational	NR	22.23 (20.74–23.72)	NR	NR	NR	9
	Mardani/2009 [89]	340.00	NR	NR	140/90	Subnational	NR	13.5 (9.86–17.13)	NR	NR	NR	5
	Mih Iran/1998 [90]	26,886.00	NR	NR	160/90	National	NR	9.5 (9.2–9.9)	NR	NR	NR	6
	Mohamadi-Far/2003 [91]	6175.00	NR	NR	140/90	Subnational	NR	15.7 (14.79–16.60)	NR	NR	NR	6
	Mohtasham-Amiri Z/2018 [92]	22,541.00	0.65	NR	130/90	Regional	NR	36.9 (36.3–37.5)	NR	NR	NR	9
	Nagib/2015 [93]	1285.00	NR	NR	140/90	Subnational	NR	11.43 (9.69–13.18)	NR	NR	NR	5
	Naghavi M/2000 [94]	1359.00	NR	NR	140/90	Subnational	NR	20.96 (16.4–25.53)	NR	NR	NR	6
	Najafipour H/2014 [95]	5895.00	NR	NR	140/90	Subnational	32.4 (31.2–33.6)	18.4 (17.41–19.38)	66.5 (63.5–67.8)	NR	28.7 (26.7–30.8)	7
	Namayandeh S/2011 [96]	1993.00	1.18	NR	140/90	Subnational	44.7 (42.5–46.9)	42.5 (40.3–44.7)	53.7 (50.3–57.1)	44.9 (41.5–48.3)	15.2 (12.9–17.8)	9
	Nikparvar M/2019 [97]	5065.00	NR	NR	130/90	Subnational	NR	23.3 (22.1–24.4)	28.3 (25.7–30.9)	17.7 (15.5–20)	7.2 (5.8–8.8)	6
	Palafox B/2016 [98]	6013.00	1.35	48.5	140/90	Multinational	NR	26.6 (23.6–29.8)	52.6(45.7–59.5)	51.1 (44.5–57.6)	18.3 (13.4–24.6)	10
	Peymani P/2012 [99]	1976.00	1.02	39.6±14.2	140/90	Subnational	NR	22.4 (21.1–23.7)	NR	NR	NR	10
	Rajati F/2019 [100]	10,040.00	0.90	NR	130/90	Regional	NR	15.7 (15–16.4)	80.7 (78.7–82.6)	73.2 (70.9–75.3)	53.3 (50.8–55.8)	9
	Ramezani M/2009 [101]	3760.00	1.00	NR	140/90	National	NR	20.7 (19.4–22)	40.3 (36.8–43.8)	31.1 (27.8–34.4)	6.2 (4.6–8.1)	10
	Ramezankhani/2016 [102]	6205.00	NR	NR	140/90	Subnational	NR	23.6 (22.6–24.7)	NR	NR	NR	7
	Rezazadehkermani/2008 [103]	93,661.00	NR	NR	140/90	National	NR	22.06 (18.92–25.19)	NR	NR	NR	6
	Roohafza H/2016 [104]	9544.00	1.00	38.7±5.5	140/90	Subnational	NR	17.5 (16.8–18.3)	49.9(47.5–52.4)	NR	NR	10
	Sadeghi M/2004 [105]	12,494.00	0.92	38.99±15.30	140/90	Subnational	NR	17.3 (16.6–17.9)	NR	38.6 (36.5–40.7)	4.5 (3.6–5.4)	10

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Sadeghi E/2015 [106]	1207.00	NR	NR	140/90	Subnational	NR	17.3 (15.16–19.43)	NR	NR	NR	6
	Safari Moradabadi/2014 [107]	1531.00	NR	NR	140/90	Subnational	NR	35.3 (32.90–37.69)	NR	NR	NR	6
	Sahraki, M. R./2011 [108]	2300.00	1.00	NR	140/90	Subnational	NR	27.1 (25.3–28.9)	NR	NR	NR	8
	Sarraf Zadegan/1999 [109]	8624.00	0.66	NR	160/90	Subnational	NR	34.8 (33.8–35.8)	55.2 (53.4–57)	51 (49.2–52.8)	12.33 (11.15–13.50)	8
	Sarrafzadegan/1997 [110]	8639.00	NR	NR	160/90	Subnational	NR	27 (26.06–27.93)	NR	NR	NR	6
	Sarrafzadegan/1999 [111]	2200.00	NR	NR	160/90	Subnational	NR	28.1 (26.22–29.97)	NR	NR	NR	6
	Sepanlou S/2015 [112]	46,674.00	1.35	NR	140/90	Subnational	33.8 (33.3–34.2)	40.1 (39.6–40.5)	NR	NR	NR	10
	Shirani S/2009 [113]	12,514.00	0.96	38.9	140/90	Subnational	NR	17.3 (16.6–18)	40.3 (38.2–42.4)	35.4 (33.4–37.4)	9.1 (8–10.4)	9
	Tabrizi J S/2016 [114]	2818.00	0.94	NR	140/90	Subnational	47.3 (45.4–49.2)	22.6 (21–24.2)	NR	NR	NR	7
	Talayi/2014 [115]	3283.00	NR	NR	140/90	Subnational	NR	25.4 (23.91–26.88)	NR	NR	NR	6
	Taleban A/1999 [116]	1000.00	NR	NR	140/90	Subnational	NR	19.68 (7.21–32.15)	NR	NR	NR	6
	Veghari G/2012 [117]	3497.00	NR	NR	140/90	Subnational	NR	21.2 (19.8–22.6)	58.7 (55.1–62.3)	51 (47.3–54.7)	21.9 (18.9–25)	9
	Yazdan Panah/2015 [118]	944.00	NR	NR	140/90	Subnational	NR	17.6 (15.17–20.02)	NR	NR	NR	6
	Yazdanpanah/1998 [119]	2000.00	NR	NR	140/90	Subnational	NR	15.8 (11.87–19.72)	NR	NR	NR	5
	Yusufali, A. M./2017 [120]	6013.00	0.92	NR	140/90	Multinational	NR	28 (26.9–29.2)	45 (42.6–47.4)	19.4 (17.5–21.3)	7.2 (6–8.5)	9
	Zarei M/1996 [121]	450.00	NR	NR	140/90	Subnational	NR	17.74 (10.15–25.33)	NR	NR	NR	5
Iraq	Saka Mh/2019 [122]	1480.00	0.32	46.4 ± 16.3	130/90	Subnational	NR	54.7 (52.1–57.2)	46.4 (42.9–49.9)	40.8 (37.4–44.3)	15.6 (13.1–18.3)	9
Israel	Abu Saad K/2014 [123]	763.00	1.03	52	140/90	Subnational	40 (36.5–43.5)	30.5 (27.3–33.9)	NR	NR	NR	8
	Amad S/1996 [124]	412.00	1.34	38.4 ± 18	160/90	Regional	NR	26.7 (22.5–31.2)	10 (5.1–17.2)	NR	NR	7

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
Jordan	Ministry Of Health, Jordan,/2007 [125]	778.00	NR	NR	140/90	National	NR	28.4 (25.3–31.7)	69.4 (66–72.6)	66.3 (62.1–70.3)	37 (33–41.3)	6
	Ajlouni/1998 [126]	2836.00	NR	NR	160/90	Subnational	NR	19.1 (17.65–20.54)	NR	NR	NR	6
	Jaddou H/2000 [127]	545.00	0.59	NR	140/90	National	NR	16.3 (12.99–19.31)	67.82 (56.94–77.44)	NR	26.44 (17.55–36.98)	8
	Jaddou H/2011 [128]	4117.00	0.34	NR	140/90	National	NR	32.3 (30.9–33.7)	56.1 (53.4–58.8)	35.5 (32.9–38.2)	14.1 (12.2–16.1)	9
	Jaddou H/2003 [129]	366.00	0.43	NR	140/90	Subnational	NR	10.9 (7.9–14.6)	52.5 (36.1–68.5)	NR	NR	8
	Khader Y/2019 [130]	4056.00	0.42	43.8	130/90	National	NR	32.1 (30.7–33.6)	60.7 (57.9–63.3)	NR	20.3 (18.2–22.6)	9
Saudi Arabia	Abolfotouh A/1996 [131]	3969.00	NR	NR	130/90	Regional	NR	11.1 (10.2–12.2)	23.5 (19.7–27.8)	17.9 (14.4–21.8)	4.8 (3–7.2)	6
	Al Baghli N/2009 [132]	197,681.00	NR	NR	140/90	Subnational	NR	13 (12.9–13.2)	NR	NR	34.3 (33.7–34.9)	7
	Al Nozha M/1997 [133]	13,700.00	NR	NR	160/90	National	NR	9.1 (8.6–9.6)	NR	NR	NR	7
	Al Shammari/1994 [134]	1005.00	NR	NR	160/90	Subnational	NR	11.1 (9.15–13.04)	NR	NR	NR	6
	Aldiab A/2018 [135]	1019.00	0.60	NR	130/90	Subnational	54.9 (51.7–57.9)	4.90 (3.58–6.23)	NR	NR	NR	9
	Al-Nozha M/2007 [136]	17,230.00	0.88	NR	140/90	National	NR	26.1 (25.4–26.8)	NR	NR	NR	9
	Al-Nozha, M. M./1998 [137]	5,883.00	NR	NR	160/90	Subnational	NR	7.8 (7.1–8.5)	NR	NR	NR	6
	El Bcheraoui/2014 [138]	10,735.00	0.96	NR	140/90	National	40.6 (39.7–41.5)	15.2 (14.5–15.9)	42.2 NR	36.8 NR	16.6 NR	8
	Elkhalifa A/2011 [139]	243.00	NR	NR	140/90	Subnational	NR	22.6 (17.5–28.4)	NR	NR	NR	6
	Osman/2000 [140]	6253.00	NR	NR	140/90	National	NR	20.4 (19.40–21.39)	NR	NR	NR	6
	Palafox B/2016 [98]	1729.00	0.41	46.5	140/90	Multinational	NR	29.8 (27.1–32.6)	61.9 (56.8–66.9)	60 (55.2–64.6)	32.8 (28.5–37.5)	10
	Saeed A/2011 [141]	4758.00	0.96	NR	140/90	National	NR	25.5 (24.3–26.8)	44.7 (41.9–47.5)	32.1 (29.4–34.8)	11.9 (10.1–13.8)	6
	Saeed A/2011 [141]	2427.00	NR	NR	140/90	National	NR	23.84 (22.15–25.54)	52.94 (48.88–57.01)	30.18 (26.44–33.92)	15.30 (12.37–18.23)	6

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Saeed A/2011 [141]	2331.00	NR	NR	140/90	National	NR	27.22 (25.41–29.02)	37.17 (33.41–40.93)	27.53 (24.05–31.01)	27.53 (24.05–31.01)	9
	Soyanwo/1997 [142]	2222.00	NR	NR	160/90	Subnational	NR	23.6 (21.83–25.36)	NR	NR	NR	10
	Wahid/1996 [143]	1394.00	NR	NR	160/90	Subnational	NR	15.4 (13.50–17.29)	73.4NR	73.4NR	69NR	6
	Warsy/1999 [144]	14,660.00	NR	NR	160/90	National	NR	4.4 (4.06–4.73)	NR	NR	NR	6
	Yusufali, A. M./2017 [120]	2041.00	1.32	NR	140/90	Multinational	NR	36 (33.9–38.1)	55.9 (52.2–59.5)	29.7 (26.4–33.1)	15.1 (12.6–17.9)	10
Lebanon	Cherfan M/2018 [145]	2014.00	0.94	41.3	130/90	National	NR	31.2 (29.2–33.3)	NR	59.6 (55.6–63.4)	28.7 (25.2–32.4)	10
	Khogali/2000 [2, 146]	764.00	NR	NR	140/90	Subnational	NR	18.2 (15.5–21.1)	NR	NR	NR	10
	Khogali/2000 [2, 146]	444.00	NR	NR	140/90	Subnational	NR	30.9 (26.6–35.4)	NR	NR	NR	6
	Matar, D/2015 [147]	1697.00	1.27	42.9 ± 15.8	140/90	National	30 (27.8–32.2)	36.9 (34.6–39.2)	53.2 (49.2–57.2)	48.9 (46.45–51.26)	54.21 (51.18–56.6)	9
	Mouhtadi B/2018 [148]	1362.00	0.97	31	130/90	National	NR	29.3 (26.9–31.8)	26.6 (22.3–31.2)	17.3 (13.7–21.4)	9.5 (6.8–12.8)	10
	Noubani A/2018 [149]	500.00	0.56	45.4 ± 15	130/90	Subnational	25.3 (21.6–29.4)	36.3 (32.1–40.7)	65.4 (58–72.3)	56.6 (49.1–63.9)	34.6 (27.7–42)	6
	Tohme R/2005 [150]	2110.00	1.22	NR	140/90	National	NR	21.6 (19.9–23.5)	NR	NR	NR	6
MENA	Beaney T/2019 [151]	93,465.00	1.36	36.6	130/90	Multinational	NR	26.3 (26–26.6)	35.7 (35.1–36.3)	32.1 (31.8–32.4)	18.8 (18.5–19.1)	6
Morocco	Moroccan Survey/2001 [152]	2000.00	NR	NR	140/90	Subnational	NR	33.6 (31.5–35.7)	NR	NR	NR	6
	Tazi/2003 [152]	1802.00	0.72	NR	140/90	National	NR	39.6 (37.4–41.9)	NR	NR	NR	9
North Africa	Adeloye D/2014 [153]	28,046.00	NR	54.3	140/90	Subnational	NR	33.3 (32.7–33.9)	36.2 (35.2–37.2)	NR	NR	7
Oman	Alriyami and Afifi/2003 [154]	7011.00	1.00	NR	140/90	National	NR	25.2 (24.2–26.2)	NR	NR	NR	10
	El-Aty M/2015 [155]	3478.00	NR	NR	140/90	National	NR	41.5 (39.47–42.77)	25.03 (22.81–27.37)	NR	NR	7
	Hasab Aa/1999 [156]	4732.00	NR	NR	140/90	Regional	NR	27 (25.73–28.26)	NR	NR	34.5NR	6

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
Palestine	Abdul-Rahim/2000 [157]	492	NR	NR	140/90	Regional	NR	21.5 (17.99–25.44)	NR	NR	NR	6
	Abdul-Rahim/2000 [157]	500	NR	NR	140/90	Regional	NR	25.4 (21.64–29.45)	NR	NR	NR	5
	Khdour M/2013 [158]	2077.00	0.72	NR	140/90	Subnational	NR	27.6 (25.7–29.6)	51 (46.8–55.1)	40.1 (36.1–44.3)	9.4 (7.2–12.1)	9
	Shahwan A/2019 [159]	2240.00	1.00	NR	130/90	Regional	NR	28.4 (26.5–30.3)	NR	NR	NR	8
	Yusufali, A. M./2017 [120]	1545.00	1.01	NR	140/90	Multinational	NR	38 (35.6–40.5)	57.1 (53–61.1)	30.2 (26.5–34)	13.1 (10.15–16.1)	10
Qatar	Bener A/2004 [160]	1208.00	0.73	NR	140/90	National	NR	32.1 (29.5–34.8)	NR	NR	NR	9
Syria	Maziak W/2007 [161]	2308.00	0.82	35.3	140/90	Subnational	NR	40.6 (38.5–42.8)	11.8 (10.4–13.9)	8.5 (7.3–9.9)	NR	8
Tunisia	Ben Romdhane/2012 [162]	8007	NR	49.6	140/90	Subnational	NR	30.6 (95% CI, NR)	NR	NR	NR	5
	Allal-Elasmi/2012 [163]	2712	NR	44.6	140/90	Subnational	NR	31.07 (95% CI, NR)	NR	NR	NR	5
	Ben Romdhane/2005 [164]	1837	NR	54.5	140/90	Subnational	NR	44.3 (95% CI, NR)	NR	NR	NR	8
	Ghanem H/1997 [165]	957.00	NR	54.5	160/90	Subnational	NR	18.8 (16.4–21.4)	NR	NR	NR	5
	Altun B/2005 [166]	4910.00	1.00	NR	140/90	National	NR	31.8 (30.5–33.1)	40.7 (37.5–44.1)	31.2 (28.1–34.3)	8.1 (6.4–10.1)	10
	Arici M/2010 [167]	3768.00	NR	NR	140/90	National	NR	21.4 (20.1–22.7)	NR	NR	NR	7
	Chow C/2013 [168]	4002.00	0.65	49.7	140/90	Multinational	NR	39.7 (38.2–41.2)	NR	NR	NR	10
	Dastan L/2018 [169]	12,971.00	NR	NR	130/90	National	NR	27.1 (26.34–27.87)	65 (64.17–65.82)	59 (57.3–60.7)	30 (28.4–31.6)	7
	Erem/2001 [170]	2646.00	NR	NR	140/90	Subnational	NR	20.2 (18.67–21.72)	NR	NR	NR	6
	Erem C/2008 [171]	4809.00	0.85	40.56 ± 14.41	140/90	Subnational	14.5 (13.5–15.5)	44 (42.6–45.5)	41 (38.9–43.2)	22.3 (20.6–24.2)	5.43 (4.46–6.39)	9
	Gokcel/2003 [172]	1637.00	NR	NR	140/90	Subnational	NR	32.9 (30.62–35.17)	NR	NR	NR	6
	Gundogan K/2009 [173]	767.00	NR	NR	140/90	Subnational	NR	41.5 (37.9–45)	NR	NR	NR	6

Table 4 (continued)

Country	Author/year [reference]	Sample size	Male/female ratio	Mean age ± SD	Hypertension definition	Level of study	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)	QA
	Mahley/1995 [174]	9000.00	NR	NR	160/90	National	NR	19.7 (18.87–20.52)	NR	NR	NR	6
	Metintas, S/2009 [175]	3000.00	NR	NR	140/90	Subnational	NR	53.6 (51.8–55.4)	NR	NR	NR	6
	Palafox B/2016 [98]	4060.00	0.65	50	140/90	Multina-tional	NR	39.3 (26.3–42.3)	57.1 (53.1–60.9)	50.7 (46.6–54.8)	20.7 (16.9–25)	10
	Sariisik A/2009 [176]	1222.00	0.84	NR	140/90	Regional	NR	33.6 (31–36.4)	59.4 (54.4–64.2)	27.74 (23.46–32.34)	8.8 (6.2–11.9)	9
	Satman/2002 [177]	24,788.00	NR	NR	140/90	National	NR	29 (28.43–29.56)	NR	NR	NR	6
	Sengul S/2013 [178]	5437.00	NR	NR	140/90	National	NR	30.3 (29.1–31.6)	54.7 (52.2–57.1)	47.2 (44.8–49.7)	28.7 (26.5–30.9)	5
	Sonmez H/1999 [179]	1466.00	0.80	NR	160/90	Subnational	NR	22.5 (20.4–24.7)	70.9 (65.7–75.8)	62.7 (57.3–68)	23.9 (19.4–28.9)	8
	Sonmez H/1999 [179]	1466.00	0.80	NR	140/90	Subnational	NR	29.7 (27.3–32.1)	57.9 (53.1–62.6)	47.6 (42.8–52.4)	9.4 (6.8–12.6)	6
	Tezcan/2003 [180]	1672.00	NR	NR	140/90	Subnational	NR	16.1 (14.33–17.86)	NR	NR	NR	9
	Tugay A/2002 [181]	1992.00	0.63	NR	140/90	Subnational	NR	32.19 (30.18–34.25)	44.4 (40.5–48.2)	37.7 (34–41.6)	9.17 (7.09–11.63)	10
UAE	Baynouna M/2008 [182]	817.00	NR	NR	140/90	Subnational	NR	20.8 (18.1–23.8)	NR	NR	NR	8
	Baynouna et al./2008 [182]	817.00	0.96	NR	140/90	Regional	NR	37.3 (34–40.8)	NR	NR	NR	8
	Chow C/2013 [168]	918.00	0.41	49.14	140/90	Multina-tional	NR	40.8 (40.5, 41.0)	NR	NR	NR	9
	Palafox B/2016 [98]	918.00	0.92	49.2	140/90	Multina-tional	NR	52.5 (48.7–55.2)	51.8 (47.3–56.3)	50.3 (45.8–54.8)	13.2 (10.4–16.6)	9
	Yusufali A/2019 [183]	6193.00	1.74	39.2	130/90	National	NR	30.1 (29–31.3)	43.5 (41.3–45.8)	56.5 (54.2–58.7)	33.6 (31.4–35.8)	6
	Yusufali, A. M./2017 [120]	917.00	0.41	NR	140/90	Multina-tional	NR	33.0 (32.0, 34.0)	47 (42.4–51.6)	21.2 (17.6–25.1)	6.5 (4.5–9.1)	10
Yemen	Gunaid/2000 [184]	1080	NR	NR	140/90	Subnational	NR	17.1 (15.45–18.75)	NR	NR	NR	6
	Modesti P/2013 [185]	10,242.00	1.03	NR	140/90	National	NR	12.8 (12.2–13.5)	44.5 (41.8–47.3)	40.4 (37.7–43.1)	9.7 (8.2–11.5)	10

Table 5 Pooled prevalence of pre-hypertension and hypertension and awareness, treatment, and control rate of hypertension using random effect model by country in the MENA region

Country*	Pre-hypertension % (95% CI)	Hypertension % (95% CI)	Awareness % (95% CI)	Treatment % (95% CI)	Control % (95% CI)
Iran	32 (22–42)	21 (20–23)	49 (44–53)	42 (36–47)	19 (16–22)
Saudi Arabia	(-)	17 (14–20)	50 (39–61)	41 (29–53)	26 (14–37)
Turkey	(-)	31 (28–35)	54 (47–62)	43 (32–53)	16 (9–23)
Jordan	(-)	23 (17–30)	61 (56–66)	40 (37–42)	24 (17–31)
Lebanon	(-)	31 (25–37)	48 (27–70)	45 (25–66)	32 (11–52)
United Arab Emirates	(-)	36 (28–43)	56 (39–73)	47 (34–60)	19 (3–35)

*Countries with more than 3 data were included in the meta-analysis

Table 6 Determinants of heterogeneity between studies of pre-hypertension and hypertension and awareness, treatment and control rate of hypertension using random effect model

Covariate	Pre-hypertension	Hypertension	Awareness	Treatment	Control
Gender	− 4.16 (2.25)	− 1.47 (0.87)	− 0.85 (2.07)	2.26 (2.33)	3.26 (1.98)
Mean age of population	0.27 (0.19)	0.21 (0.08)*	0.52 (0.25)*	0.59 (0.28)*	0.95 (0.25)**
Income level	− 22.40 (6.37)*	0.31 (1.24)	− 1.59 (2.77)	− 0.66 (3.12)	− 3.78 (2.53)
Country	− 0.68 (0.75)	0.59 (0.14)**	− 0.39 (0.31)	0.03 (0.42)	0.40 (0.32)
Definition	0. − 3.92 (4.97)	− 0.53 (1.11)	5.31 (2.48)*	− 0.59 (0.28)**	6.20 (2.34)*
Level of study	11.63 (4.89)*	2.21 (0.81)*	− 0.18 (1.89)	0.37 (2.30)	− 0.03 (1.93)*

Data are presented as β coefficient (standard error)

*< 0.05; **< 0.001 significant levels

Compliance with Ethical Standards

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