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Hypertension awareness, treatment and control among ethnic minority populations in Europe: a systematic review and meta-analysis

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Objective: Ethnic minority populations (EMPs) are disproportionally affected by hypertension-mediated complications compared with European host populations (EHPs), which might be due to disparities in hypertension awareness, treatment and control. We conducted a systematic review and meta-analysis to compare awareness, treatment and control rates among EMPs with EHPs.

Methods: MEDLINE, EMBASE and Web of Science were searched from inception to 29 January 2020. Critical appraisal was performed according to methods of Hoy *et al.* Pooled odds ratios with corresponding 95% confidence intervals were calculated for these rates, stratified by ethnic group, using either random or fixed effect meta-analysis based on I^2-statistics. Study was registered in PROSPRO (CRD42020107897).

Results: A total of 3532 records were screened of which 16 were included in the analysis with data on 26 800 EMP and 57 000 EHP individuals. Compared with EHPs, African origin populations were more likely to be aware (odds ratio 1.26, 95% confidence interval 1.02–1.56) and treated (1.49, 1.18–1.88) for hypertension, but were less likely to have their blood pressure controlled (0.56, 0.40–0.78), whereas South Asian populations were more likely to be aware (1.15, 1.02–1.30), but had similar treatment and control rates. In Moroccan populations, hypertension awareness (0.79, 0.62–1.00) and treatment levels (0.77, 0.60–0.97) were lower compared with EHPs, while in Turkish populations awareness was lower (0.81, 0.65–1.00).

Conclusion: Levels of hypertension awareness, treatment and control differ between EMPs and EHPs. Effort should be made to improve these suboptimal rates in EMPs, aiming to reduce ethnic inequalities in hypertension-mediated complications.

Keywords: ethnic minority population, ethnicity, Europe, hypertension awareness, hypertension control, hypertension treatment

Abbreviations: BP, blood pressure; CI, confidence interval; CVD, cardiovascular disease; EHP, European host population; EMP, ethnic minority population; EU, European Union; OR, odds ratio; SSA, sub-Saharan Africa

INTRODUCTION

Hypertension is the major modifiable risk factor for cardiovascular disease (CVD) morbidity and mortality. In Europe, over 50% of the CVD deaths is attributable to high SBP [1]. Mean blood pressure (BP) levels vary between ethnic minority and the European host population (EHP) [2], and hypertension-mediated CVD burden is not equally distributed between populations of different ethnic background. For instance, the prevalence of stroke is up to 2.1 times higher in sub-Saharan African (SSA) origin populations compared with the EHP [3], which is mainly attributable to the higher prevalence of hypertension [4].

BP-lowering therapy (i.e. medication, lifestyle modification) results in a considerable reduction in CVD morbidity and mortality [5] and early detection, adequate treatment and control of hypertension can lead to significant health and economic gains [6]. However, globally, less than half (47%) of the adults with hypertension is aware of their condition, 37% receives treatment, and 37% of those who are prescribed antihypertensive medication have their BP adequately controlled [7]. Studies from the USA show variation in these rates between populations of different ethnic origin [8]. Individual studies from Europe show similar patterns [9], however, systematically aggregated data comparing awareness, treatment and control levels among ethnic minority populations (EMPs) to the EHP are lacking. To reduce the ethnic inequalities in the CVD burden, improving hypertension control rates is vital. Whereas

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ethnic differences in hypertension prevalence are mainly determined by gene-environment interactions, hypertension awareness, treatment and control rates are principally determined by health behaviour (e.g. medication adherence) and healthcare-related factors (e.g. access to healthcare). Therefore, aggregated data on hypertension awareness, treatment and control, as well as on ethnic differences in these variables will help to optimize the allocation of healthcare resources and can guide culturally targeted preventive efforts, which is crucial for the ethnically diverse societies that Europe consists of today. Therefore, the aim of this systematic review and meta-analysis was to assess the levels of hypertension awareness, treatment and control among EMPs in Europe, compared with the EHP.

METHODS

Search strategy and selection criteria

For this systematic review and meta-analysis, all longitudinal or cross-sectional studies published in a peer-reviewed journal, that reported prevalence of hypertension awareness, treatment and/or control, conducted in an adult population (≥16 years), and compared one or more minority ethnic groups to the EHP, were eligible for inclusion. No language restriction was applied. Studies not defining the ethnic origin of the group under study, studies conducted outside Europe, non-population-based studies, studies defining hypertension based on a single BP reading or on self-report only, were excluded. To be able to draw general conclusions, studies or populations with a sample size of less than 100 participants were excluded. Search terms were developed by a medical librarian (J.G.D.) in collaboration with the research group, based on a scoping search to identify relevant search concepts. Reference list of primary studies were screened, tracked citations in GoogleScholar were checked, and trial registers searched to identify additional relevant studies. MEDLINE (OvidSP) (1946 to date), EMBASE (OvidSP) (1980 to date) and Web of Science (inception to date) were searched using (controlled) terms for the following relevant search concepts, adapted to the criteria of the specific database searched: 'Hypertension', 'Europe', 'Minority ethnic population', 'Awareness', 'Treatment', 'Control' (Supplementary Digital Content 1, http://links.lww.com/HJH/B459). The search terms were combined using Boolean terms AND and OR; NOT terms were identified based on bibliometric mapping of the MEDLINE and EMBASE search results using VOSviewer software (VOSviewer version 1.6.9. Leiden: Centre for Science and Technology Studies, 2018). No time limit was applied; studies conducted in animals were excluded. Search results were deduplicated before study selection.

Study selection was performed by one reviewer (E.L.v.d.L.), based on screening of title and abstract, using Rayyan application for systematic reviews (Rayyan Qatar Computing Research Institute). Hereafter, full-text screening was performed by two reviewers independently (E.L.v.d.L. and B.N.C.). Disagreements were solved through discussion and decision on inclusion was made upon the two author's opinion. Corresponding authors were contacted in case of unavailable full text or conference abstracts.

The systematic review and meta-analysis was performed in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines [10], and was prospectively registered in PROSPERO (CRD42020107897).

Data analysis

For the included studies, a table format was used to extract data on study and population characteristics, and outcome measures [prevalence with corresponding 95% confidence interval (CI) of hypertension, and hypertension awareness, treatment and control], by both reviewers (E.L.v.d.L. and B.N.C.) independently. If results from the same study were published multiple times, the article reporting the most complete data were included. Corresponding authors were contacted by e-mail in case of incomplete outcome data.

Hypertension awareness was defined as the proportion of individuals with hypertension reporting any prior diagnosis of hypertension by a healthcare professional. Hypertension treatment was defined as the proportion of participants with hypertension being on treatment, with treatment defined by original authors as receiving prescribed BP-lowering medication or antihypertensive treatment not otherwise specified. Hypertension control was defined in two ways: first, as the proportion of participants receiving BP-lowering treatment with systolic BP (SBP) and diastolic (BP) below 140/90 or 160/95 mmHg and second, as the proportion of participants with hypertension reaching a SBP and DBP below 140/90 or 160/95 mmHg.

Risk of bias of the individual studies was assessed using the Risk of Bias Tool in population-based prevalence studies by Hoy *et al.* [11], including four items assessing internal and six items assessing external validity of the identified studies, classifying them into low, moderate or high risk of bias categories. Studies with low or moderate risk of bias were included in the meta-analysis. One study was excluded from meta-analysis of hypertension control rates, because it used a different case definition [12].

Unweighted pooled prevalence rates for hypertension awareness, treatment and control for the various populations were derived from the numbers reported by the original authors. To compare levels of hypertension awareness, treatment and control between EMPs and the EHP, data on proportions of hypertension awareness, treatment and control among those being treated were pooled, resulting in odds ratios (OR) with corresponding 95% CI, weighted for sample size according to the Mantel–Haenszel method [13]. Heterogeneity between studies was assessed using the I^2 statistic. For the meta-analysis a random-effects model was used if the Q test for heterogeneity was significant ($P < 0.05$) and fixed-effects model in case of non-significance ($P > 0.05$). Meta-analysis was visualized in Forrest plots, using Review Manager (version 5.3; Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) and R Statistics version 3.6.2 [R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria]. For the meta-analysis, data were analysed separately for those studies using higher (SBP ≥ 160 mmHg and/or DBP ≥ 95 mmHg) and lower (≥140 mmHg SBP and/or

≥90 mmHg DBP) BP threshold to define hypertension, and results were stratified by sex and EMP. EMPs were grouped by their geographical region of origin as per categorization of the United Nations World Regions [14]. Pooled groups were African, South Asian, Moroccan, Turkish, Chinese origin populations; see Supplementary Digital Content three for specification on subpopulations included per pooled group, http://links.lww.com/HJH/B459. The African origin group consisted of African Caribbean and SSA populations. The South Asian origin population comprised of South Asian Surinamese and South Asian populations. These distinctions within the African and South Asian origin populations were made to allow comparison between groups with differences in migration history, that is those who migrated directly from SSA and South Asian to Europe, and those with SSA or South Asian ancestral origin who migrated to Europe via the Caribbean (including Suriname). The EHP was defined as the population of European origin living in one of the 27 members European Union (EU) member states, the United Kingdom, Norway or Switzerland, or specified by the original author as European, White, Caucasian, European Caucasian, native Dutch, native Portuguese or Italian.

RESULTS

Primary search was performed on 13 September 2018 and was updated on 29 January 2020, identifying 2002 studies in MEDLINE, 1600 studies in EMBASE and 2164 studies in Web of Science; six studies were identified through other sources (reference checking of primary studies and tracked citations in GoogleScholar). After removal of duplicates, 4160 records were screened, of which 4068 were excluded based on title and abstract. A total of 92 full-text articles were screened, and after exclusion of 76 studies, 16 studies were included for analysis (for flowchart, Supplementary Digital Content 3, http://links.lww.com/HJH/B459).

Included studies reported data of approximately 57 000 Europeans, 12 000 African origin (African Caribbean $n=6800$, SSA $n=2310$), 7600 South Asian origin (South Asian Surinamese $n=2500$, South Asian $n=5000$), 2700 Turkish, 2600 Moroccan and 1900 Chinese participants (Table 1), residing in the United Kingdom [12,15–24], the Netherlands [25–27], Portugal [28] or Italy [29]. 14 studies had a cross-sectional study design [15–23,25–29] and were conducted in urban areas; two studies [12,24] included nation-wide survey data. Ethnicity was mainly defined based on (self-reported) country of birth, (grand-) parental origin and/or self-reported ethnicity.

Prevalence of hypertension awareness was reported in seven studies [12,15,23,25–27,29], treatment in 13 studies [15–22,24–27,29], and control in 10 studies [12,15,19,22,24–29]. Of the 16 included studies, eight used the higher BP cut-off [15–21,24] (Supplementary Digital Content 4, http://links.lww.com/HJH/B459) and eight used the lower BP cut-off to define hypertension [12,22,23,25–29] (Table 2). Generally, hypertension prevalence was higher among African origin populations compared with the EHP, but lower in Moroccan and Turkish origin populations.

Hypertension awareness rates were highest in African, South Asian origin and EHPs, both in studies using the higher cut-off to determine hypertension, as well as in studies using the lower cut-off, whereas Turkish and Moroccan populations had lowest levels of awareness (Fig. 1a and c). This was reflected in the meta-analysis of the studies using the lower BP cut-off to define hypertension, showing higher odds of being aware for African (OR 1.26, 95% CI 1.02–1.56, $I^2=63\%$) and South Asian origin (OR 1.15, 1.02–1.30, $I^2=44\%$), but lower odds for Turkish (OR 0.81, 0.65–1.00, $I^2=41\%$) and Moroccan (OR 0.79, 0.62–1.00, $I^2=47\%$) populations compared with the EHP (Figs 2–5). OR for awareness did not differ between Chinese and European populations (Fig. 6).

Hypertension treatment levels were generally higher in studies using the higher BP cut-off than in studies using the lower BP cut-off for hypertension. African origin populations had highest treatment levels, whereas Moroccan populations had lowest treatment levels (Fig. 1a and c). The meta-analysis of studies reporting on hypertension treatment showed higher OR in African origin than in the EHP, both in studies using the higher (OR 1.78, 1.44–2.19, $I^2=18\%$, Supplementary Digital Content 5, http://links.lww.com/HJH/B459) and lower (OR 1.49, 1.18–1.88, $I^2=61\%$) BP cut-off for hypertension (Fig. 2). No difference in odds of receiving antihypertensive treatment could be observed between South Asian origin (higher BP cut-off OR 0.96, 0.76–1.21, $I^2=0\%$; Supplementary Digital Content 6, http://links.lww.com/HJH/B459), lower BP cut-off OR 1.25, 0.72–2.17, $I^2=83\%$ (Fig. 3), Turkish (lower BP cut-off OR 0.88, 0.54–1.41, $I^2=73\%$) and the EHPs, although a trend towards lower OR of being treated could be observed for Turkish men compared with their European counterparts (OR 0.75, 0.55–1.02, $I^2=0\%$) (Fig. 4). Moroccans were less likely to receive treatment compared with the EHP (OR 0.77, 0.60–0.97, $I^2=45\%$) (Fig. 5).

Hypertension control rates among those on treatment were lowest in African origin populations, whereas South Asian origin populations most frequently reached adequate BP control (Fig. 1a and c). Similar trends could be observed for the prevalence of hypertension control as proportion of all hypertensive participants (Table 2). Compared with the EHP, African origin populations were less likely to have their BP controlled despite being on treatment (lower BP threshold, OR 0.51, 0.37–0.71, $I^2=67\%$), both in SSA and African Caribbean populations and in both men and women (Fig. 2). South Asian origin populations had a trend towards lower pooled odds of reaching BP control compared with the EHP (OR 0.76, 0.57–1.03, $I^2=0\%$), although this was only significant for South Asian Surinamese men compared with their Dutch counterparts (OR 0.65, 0.42–0.98, $I^2=0\%$) (Fig. 3). Turkish and Moroccan populations did not differ from the EHP in terms of BP control, although a trend towards lower odds could be observed in Turkish (OR 0.88, 0.63–1.22, $I^2=0\%$) and Moroccan populations (OR 0.78, 0.53–1.13, $I^2=0\%$) compared with the EHP (Figs. 4 and 5).

Of the 16 studies included for analysis, 10 had moderate risk of bias [16–22,24,27,28] and six studies had low risk of bias [12,15,23,25,26,29] (Supplementary Digital Content 7, http://links.lww.com/HJH/B459). With regard to the external validity of the studies, most studies had moderate risk of bias, because the target study population was not a close

TABLE 1. Characteristics of studies included in analysis

Reference	Study design: a. Place b. Study period c. Study design d. Sampling method	Study characteristics: Indicator of ethnicity	Ethnic groups	*n* (% women)	Response/ Participation rate	Population characteristics	Age range (years), mean (SD or CI)	BMI (kg/m²) or obesity (BMI > 30)	Fasting plasma glucose or diabetes mellitus
Agyemang *et al.* [25]	a. South-East Amsterdam, The Netherlands b. 2001–2003 c. Cross-sectional d. Random sample from municipality register	Country of birth or parental country of birth, self-reported maternal ethnic origin	White Dutch: African Surinamese: SA Surinamese:	508 (50.2) 581 (67.8) 294 (45.1)	61% 60% (African + SA Surinamese)		35–60		n/a
						Men		Mean (CI)	
						White Dutch:	48.1 (47.3–48.9)	26.2 (25.7–26.8)	
						African Surinamese:	44.1 (43.2–44.9)	26.4 (25.7–27.0)	
						SA Surinamese:	44.3 (43.2–45.4)	26.4 (25.5–27.2)	
						Women			
						White Dutch:	47.4 (46.6–48.2)	26.1 (25.5–26.8)	
						African Surinamese:	43.3 (42.9–44.0)	29.4 (28.8–29.9)	
						SA Surinamese:	45.0 (44.0–46.0)	27.5 (26.7–28.3)	
Agyemang *et al.* [27]	a. Amsterdam, The Netherlands b. 2004 c. Cross-sectional d. Random sample from municipality register	Self-reported country of birth or parental country of birth	Native Dutch: Turkish: Moroccan:	511 (58.5) 433 (53.6) 360 (45.8)	46% 50% 39%		≥18		
						Men		Mean (CI)	%
						Native Dutch:	51.5 (49.5–53.6)	25.7 (25.2–26.3)	7.5
						Turkish:	48.7 (46.9–50.5)	28.1 (27.5–28.7)	17.0
						Moroccan:	52.4 (50.5–54.2)	27.0 (26.5–27.6)	11.0
						Women			
						Dutch:	51.7 (49.9–53.5)	26.3 (25.8–26.9)	2.8
						Turkish:	43.6 (41.8–45.4)	31.1 (30.3–31.9)	12.8
						Moroccan:	44.1 (41.9–6.3)	29.7 (28.7–30.7)	11.7
Agyemang *et al.* [26]	a. Amsterdam, The Netherlands b. 2011–2014 c. Baseline data of prospective cohort d. Random sample from municipality register	Country of birth and parental country of birth	Dutch: Moroccan: Turkish: SA Surinamese: African Surinamese: Ghanaian:	2142 (54.1) 2252 (60.7) 2277 (53.8) 2278 (55.3) 2184 (63.2) 1871 (59.5)	Overall response rate: 63% Participation rate: Dutch: 54% Moroccans: 35% Turkish: 36% Surinamese: 43% Ghanaians: 57%		18–70		
						Men		Mean (CI)	mmol/l
						Dutch:	47.3 (46.4–48.2)	25.2 (25.0–25.4)	5.5 (5.4–5.5)
						Moroccan:	41.8 (40.9–42.7)	26.6 (26.3–26.9)	5.8 (5.7–5.9)
						Turkish:	40.6 (39.9–41.3)	27.9 (27.6–28.2)	5.6 (5.5–5.7)
						SA Surinamese:	45.2 (44.4–46.0)	25.7 (25.5–26.0)	6.0 (5.9–6.1)
						African Surinamese:	47.6 (46.7–48.5)	26.4 (26.1–26.7)	5.5 (5.4–5.7)
						Ghanaian:	47.1 (46.3–47.9)	26.8 (26.5–27.1)	5.6 (5.5–5.7)
						Women			
						Dutch:	45.5 (44.7–46.4)	24.3 (24.1–24.5)	5.1 (5.0–5.2)
						Moroccan	39.3 (38.6–39.9)	28.3 (28.0–28.6)	5.3 (5.2–5.4)
						Turkish:	40.3 (39.6–40.9)	29.4 (29.0–29.8)	5.3 (5.2–5.4)
						SA Surinamese:	46.7 (45.8–47.3)	26.9 (26.6–27.2)	5.6 (5.5–5.7)
						African Surinamese:	47.5 (46.8–48.2)	28.8 (28.5–29.1)	5.4 (5.3–5.5)
						Ghanaian:	43.9 (43.2–44.5)	29.5 (29.2–29.8)	5.2 (5.1–5.3)
Cappuccio *et al.* [15]	a. South London, UK b. 1994–1996 c. Cross-sectional survey d. Patient list from 9 GP practices	Name analysis, verified at interview (country of birth, language, religion, migration history, parental country of birth)	White: African descent (SSA + African Caribbean): SA:	524 (n/a) 549 (n/a) 505 (n/a)	Overall response rate 82%; participation rate 76%				
						Men + Women			
						White:	49.8 (5.6)		
						African descent:	51.1 (5.8)		
						SA:	49.4 (5.9)		
						Men		% (CI)	*n* (%)
						White:		14.8 (10.5–19.9)	181 (6.7)
						African descent:		14.8 (10.5–20.5)	157 (17.9)
						SA:		8.4 (5.3–12.4)	211 (25.4)
						Women			
						White:		18.8 (14.7–23.9)	210 (5.2)
						African descent:		39.8 (34.8–45.3)	245 (14.9)
						SA:		19.7 (15.0–25.1)	191 (20.5)

TABLE 1 (*Continued*)

Reference	Study design a. Place b. Study period c. Study design d. Sampling method	Study characteristics Indicator of ethnicity	Ethnic groups	*n* (% women)	Response/ Participation rate	Population characteristics	Age range (years), mean (SD or CI)	BMI (kg/m^2) or obesity (BMI > 30)	Fasting plasma glucose or diabetes mellitus
Chaturvedi *et al.* [16]	a. Inner London, UK b. n/a c. Cross-sectional d. Patient list from 9 GP practices	Assigned by interviewer based on appearance and parental origin	European: West African + Afro-Caribbean:	585 (53.5) 581 (57.5)	Overall response rate 58%	Men European: Afro-Caribbean: Women European: Afro-Caribbean:	40–64, n/a	Mean (CI) 26.4 (26.0–26.8) 26.0 (25.6–26.4) 26.0 (25.5–26.5) 29.1 (28.5–29.6)	% (CI) 6.5 (5.0–8.0) 12.9 (10.4–15.4) 4.0 (2.7–5.3) 17.7 (15.6–19.8)
Cruickshank *et al.* [18]	a. Birmingham, UK b. n/a c. Cross-sectional d. Health survey among employees of 12 factories	Assigned by observer based on appearance	White: Afro-Caribbean: Indian:	603 (27.2) 274 (58.0) 172 (0)	Participation rate 80%		16–64, n/a	n/a	n/a
Cruickshank *et al.* [17]	a. North West London, UK b. n/a c. Cross-sectional d. Random sample from 2 GP practices	Grandparental origin	White: Afro-Caribbean: Gujarati Indian:	101 (51.5) 106 (50.0) 107 (56.1)	Participation rate 77%	Men White: Afro-Caribbean: Gujarati Indian: Women White: Afro-Caribbean: Gujarati Indian:	45–74 62.0 (7.0) 57.0 (5.0) 62.2 (5.0) 60.3 (7.0) 56.6 (6.0) 62.2 (5.0)	Mean (SD) 26.2 (4.0) 26.0 (4.0) 25.2 (3.0) 26.3 (5.0) 29.1 (5.0) 26.8 (5.0)	*n* (%) 2 (4.0) 22 (41.5) 15 (31.9) 1 (1.9) 9 (17.0) 17 (28.3)
Cruickshank *et al.* [19]	a. Inner city Manchester, UK b. 1992–1995 c. Cross-sectional d. Random sample from population registers of 4 health centres	Grandparental origin	European: African-Caribbean:	558 (52.5) 480 (53.8)	European: n/a African-Caribbean: 66%	Men European: African-Caribbean: Women European: African-Caribbean:	25–74 51.4 (49–53) 52.5 (50–54) 52.5 (50–54) 47.5 (45–59)	n/a	n/a
Haines *et al.* [20]	a. North West London, UK b. 1983–1986 c. Cross-sectional d. All patients from 1 GP practice	Self-reported ethnic group	Whites: Blacks of Caribbean origin:	936 (51.9) 415 (54.0)	61%	Men Whites: Blacks: Women Whites: Blacks:	17–70 42.4 (15.6) 41.4 (15.6) 40.9 (15.5) 36.5 (13.8)	n/a	n/a
Knight *et al.* [21]	a. Bradford, UK b. n/a c. Cross-sectional d. Health survey among manual workers in 2 textile factories	Name analysis, self-reported origin	Asian (mainly Pakistani): Non-Asian (Europeans):	128 (0) 160 (0)	Asian 83.4% Non-Asian 70.6%	Men Asian: Non-Asian:	20–65, 41	Mean (CI) 24.5 (24.0–25.1) 25.2 (24.7–25.7)	*n* (%) 14 (10.9) 7 (4.4)
Lemic-Stojcevic *et al.* [22]	a. Inner city South London, UK b. 1995 c. Cross-sectional d. Random sample from 6 GP practices	Self-reported ethnic group	White: Black Caribbean: Black African:	291 (52.6) 310 (56.1) 102 (63.7)	Questionnaire: 45% Examination: White: 68% Black Caribbean: 73% Black African: 55%	White: Black Caribbean: Black African:	45–74 58.7 (8.0) 60.3 (7.3) 54.0 (6.2)	n/a	n/a

TABLE 1 (*Continued*)

	Study design	Study characteristics				Population characteristics			
Reference	a. Place b. Study period c. Study design d. Sampling method	Indicator of ethnicity	Ethnic groups	*n* (% women)	Response/ Participation rate		Age range (years), mean (SD or CI)	BMI (kg/m^2) or obesity (BMI > 30)	Fasting plasma glucose or diabetes mellitus
Lopes *et al.* [28]	a. Lisbon region, Portugal b. 2010–2011 c. Cross-sectional d. Random sample from 52 GP practices with high proportion of immigrant patients	Country of birth and self-reported ethnic origin	Native Portuguese: Portuguese speaking African countries immigrants:	449 (51.2) 337 (57.9)	Native Portuguese: 68% African immigrants: 75%	 Portuguese: African Immigrants:	40–80 64.2 (9.1) 57.1 (10.1)	*n* (%) 179 (47.6) 153 (51.0)	*n* (%) 120 (26.7) 92 (27.3)
Modesti *et al.* [29]	a. Prato, Tuscany, Italy b. 2014–2015 c. Baseline data from prospective cohort d. Chinese: Network sampling procedure through 4 community-based Chinese organizations; Italians: random sample from GP practices	Country of birth and grandparental country of birth	Italian: Chinese:	291 (51.2) 1200 (52.9)	Italian: 67% Chinese: n/a	 Italian: Chinese:	35–59 47.6 (7.5) 46.2 (7.1)	Mean (SD) 25.4 (3.2) 23.7 (3.1)	mg/dl 103.6 (55.5) 118.3 (33.4)
Nazroo *et al.* [12]	a. England, UK b. 1998, 1999, 2003, 2004 c. Cross-sectional, National Health Survey d. Random sample from postcode sectors	Self-reported ethnic origin of family	White: Black Caribbean: Indian: Pakistani: Bangladeshi: Chinese:	17 836 (n/a) 1067 (n/a) 1370 (n/a) 1041 (n/a) 712 (n/a) 701 (n/a)	Household response rate: General population: 74–76% Ethnic minority sample: 66–67%	 White: Black Caribbean: Indian: Pakistani: Bangladeshi: Chinese:	16–74	n/a	*n* (%) 259 (3.7) 95 (10.3) 134 (10.9) 98 (11.5) 94 (16.9) 31 (5.9)
Patel *et al.* [23]	a. Inner city Sandwell, UK b. 2005–2006 c. Cross-sectional d. 10 Pubic screening events	Self-reported ethnicity	European: Gujarati Indian: Punjabi Indian: Bangladeshi: Other Indian (Sri Lankan, South Indian, Pakistani):	276 (56.9) 79 (45.6) 163 (46.6) 160 (58.8) 68 (44.1)	Attendance rate: Indian: 80%; Bangladeshi, Pakistani: <50%	 Men European Caucasian: Gujarati Indian: Punjabi Indian: Bangladeshi: Other Indian: Women European Caucasian: Gujarati Indian: Punjabi Indian: Bangladeshi: Other Indian:	25–90, 47.7 (15.2)	BMI > 27 kg/m^2 % (CI) 48.4 (39.4–57.4) 43.1 (28.0–58.3) 40.0 (29.7–50.3) 48.2 (36.1–60.2) 56.2 (39.7–72.6) 43.7 (35.8–51.5) 37.6 (21.4–53.9) 50.1 (38.8–61.3) 47.2 (37.1–57.3) 41.0 (0–109)	 *n* (%) 4 (3.3) 8 (19.2) 14 (15.6) 23 (35.1) 2 (6.6) 3 (1.7) 8 (22.1) 5 (6.4) 25 (26.8) 3 (10.0)
Primatesta *et al.* [24]	a. England, UK b. 1991–1996 c. Cross-sectional, National Health Survey d. Multistage stratified probability sampling design	Self-reported ethnicity in predefined categories	White: Black (SSA + African Caribbean): South Asian:	31 619 (53.7) 295 (53.9) 529 (45.9)	n/a	 Men White: SSA + African Caribbean: SA: Women White: SSA + African Caribbean: SA:	≥40, n/a	*n* (%) 2633 (18) 26 (19) 34 (12) 3568 (21) 78 (49) 56 (23)	n/a

CI, confidence interval; GP, general practitioner; n/a, not available; SA, South Asian; SSA, sub-Saharan Africa.

TABLE 2. Study results of included studies using the blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension

Reference	Diagnostic method	Definition	Population	Total *n*	Prevalence, *n* (%)	Awareness[a], *n* (%)	Treatment[b], *n* (%)	Control among treated[c], *n* (%)	Control among total prevalence[d], *n* (%)
Agyemang *et al.* [25]	Automated digital BP device; mean of two BP readings on right arm	SBP ≥ 140 or DBP ≥ 90 mmHg or being on antihypertensive medication	Men						
			White Dutch:	253	104 (41.3)	57 (54.8)	35 (33.3)	15 (42.1)	15 (14.4)
			African Surinamese:	187	88 (47.1)	44 (50.0)	21 (23.9)	3 (14.3)	3 (3.4)
			SA Surinamese:	135	56 (41.5)	30 (53.6)	16 (28.6)	6 (37.5)	6 (10.7)
			Women						
			White Dutch:	255	66 (25.9)	48 (72.7)	20 (30.8)	10 (50.0)	10 (15.2)
			African Surinamese:	394	182 (46.3)	136 (74.7)	54 (29.8)	26 (48.1)	26 (14.3)
			SA Surinamese:	159	68 (42.8)	54 (79.4)	30 (44.1)	12 (40.0)	12 (17.6)
Agyemang *et al.* [27]	Automated digital BP device; mean of two BP readings on left arm	SBP ≥ 140 or DBP ≥ 90 mmHg or being on antihypertensive medication	Men						
			Dutch:	212	103 (48.8)	38 (36.6)	29 (28.6)	9 (30.0)	9 (8.7)
			Turkish:	201	51 (25.6)	14 (26.7)	10 (20.5)	3 (28.6)	3 (5.9)
			Moroccan:	195	51 (26.1)	15 (28.9)	12 (22.6)	3 (28.6)	3 (5.9)
			Women						
			Dutch:	299	105 (35.0)	56 (53.8)	56 (53.5)	9 (16.2)	9 (5.6)
			Turkish:	232	51 (22.1)	27 (52.2)	21 (41.2)	6 (26.7)	6 (11.8)
			Moroccan:	165	32 (19.6)	9 (29.0)	8 (25.9)	1 (14.3)	1 (3.1)
Agyemang *et al.* [26]	Automated digital BP device; mean of two BP readings on left arm	SBP ≥ 140 or DBP ≥ 90 mmHg or being on antihypertensive medication	Men						
			Dutch:	983	331 (33.7)	156 (47.3)	118 (35.7)	63 (53.4)	63 (19.0)
			Moroccan:	885	207 (23.9)	81 (40.1)	62 (30.5)	32 (51.6)	32 (15.5)
			Turkish:	1052	323 (30.7)	118 (37.2)	97 (30.0)	45 (46.6)	45 (13.9)
			SA Surinamese:	1018	435 (42.3)	228 (52.3)	225 (51.7)	94 (41.8)	94 (21.6)
			African Surinamese:	803	378 (47.1)	179 (47.9)	156 (41.4)	51 (32.7)	51 (13.5)
			Ghanaian:	758	449 (61.6)	253 (57.1)	204 (45.4)	55 (27.0)	55 (12.2)
			Women						
			Dutch:	1159	219 (18.9)	128 (58.8)	118 (53.9)	72 (61.0)	72 (32.9)
			Moroccan:	1367	216 (15.8)	125 (58.1)	112 (51.9)	58 (51.8)	58 (26.9)
			Turkish:	1225	279 (31.1)	168 (60.4)	180 (60.4)	103 (57.2)	103 (36.9)
			SA Surinamese:	1260	461 (36.6)	278 (61.4)	228 (62.5)	136 (47.2)	136 (29.5)
			African Surinamese:	1381	635 (46.0)	439 (69.6)	390 (61.4)	179 (45.9)	179 (28.2)
			Ghanaian:	1113	567 (50.9)	331 (59.1)	321 (56.6)	137 (42.7)	137 (24.2)
Lemic-Stojcevic *et al.* [22]	Automated digital BP device; mean of three BP readings	SBP ≥ 140 or DBP ≥ 90 mmHg or being on antihypertensive treatment (treatment not specified)	White:	291	158 (54.3)	n/a	45 (15.5)	15 (33.3)	15 (9.5)
			Black Caribbean:	310	246 (79.4)		130 (41.9)	18 (13.8)	18 (7.3)
			Black African:	102	73 (71.6)		34 (33.3)	9 (26.5)	9 (12.3)
Lopes *et al.* [28]	Unknown device; mean of three BP readings	SBP ≥ 140 or DBP ≥ 90 mmHg and being on antihypertensive medication	Native Portuguese:	449	449 (100)	n/a	n/a	212 (47.2)	212 (47.2)
			African immigrant:	337	337 (100)			153 (45.4)	153 (45.4)
Modesti *et al.* [29]	Semiautomatic device; three BP readings, mean of last two readings	SBP ≥ 140 or DBP ≥ 90 mmHg or being on antihypertensive medication	Italian:	291	62 (21.3)	30 (48.4)	27 (43.5)	12 (44.4)	12 (19.4)
			Chinese:	1200	326 (27.2)	187 (57.4)	132 (40.5)	56 (42.4)	56 (17.2)
Nazroo *et al.* [12]	Automated digital BP device; 3 BP reading, mean of last two readings on right arm	SBP ≥ 140 or DBP ≥ 90 mmHg or previous diagnosis or being on antihypertensive medication	White:	17 836	5868 (32.9)[e,f]	3621 (61.7)[e,f]	n/a	1892 (52.0)[e,f,g]	1892 (32.2)[e,f]
			Black Caribbean:	1067	380 (35.6)[e,f]	280 (73.6)[e,f]		149 (53.1)[e,f,g]	149 (39.2)[e,f]
			Indian:	1370	393 (28.4)[e,f]	259 (65.8)[e,f]		152 (58.6)[e,f,g]	152 (38.7)[e,f]
			Pakistani:	1041	218 (20.9)[e,f]	148 (67.9)[e,f]		88 (59.6)[e,f,g]	88 (40.4)[e,f]
			Bangladeshi:	712	137 (19.2)[e,f]	67 (70.8)[e,f]		41 (61.0)[e,f,g]	41 (29.9)[e,f]
			Chinese:	701	143 (20.4)[e,f]	86 (59.8)[e,f]		45 (52.5)[e,f,g]	45 (31.5)[e,f]
Patel *et al.* [23]	Semiautomatic device; three BP readings, mean of last two readings	SBP > 140 or DBP > 90 mmHg or previous diagnosis or being on antihypertensive medication	Men				n/a	n/a	n/a
			European Caucasian:	119	54 (45.1)[e]	38 (71.0)[e]			
			Gujarati Indian:	43	27 (62.4)[e]	18 (67.8)[e]			
			Punjabi Indian:	87	43 (49.6)[e]	34 (78.0)[e]			
			Bangladeshi:	66	15 (23.1)[e]	14 (93.0)[e]			
			Other Indian:	37	23 (63.5)[e]	17 (75.7)[e]			
			Women						
			European Caucasian:	157	53 (33.8)[e]	42 (78.7)[e]			
			Gujarati Indian:	36	15 (41.9)[e]	13 (85.0)[e]			
			Punjabi Indian:	76	20 (26.5)[e]	18 (88.7)[e]			
			Bangladeshi:	94	32 (33.6)[e]	28 (86.4)[e]			
			Other Indian:	31	6 (19.5)[e]	5 (85.9)[e]			

BP, blood pressure; n/a, not available; SA, South Asian; SSA, sub-Saharan African.
[a]In percentage of participants with hypertension.
[b]In percentage of participants with hypertension.
[c]In percentage of those on treatment for hypertension.
[d]In percentage of participants with hypertension.
[e]Age-adjusted.
[f]Sex-adjusted.
[g]In percentage of those being aware and/or treated for hypertension.

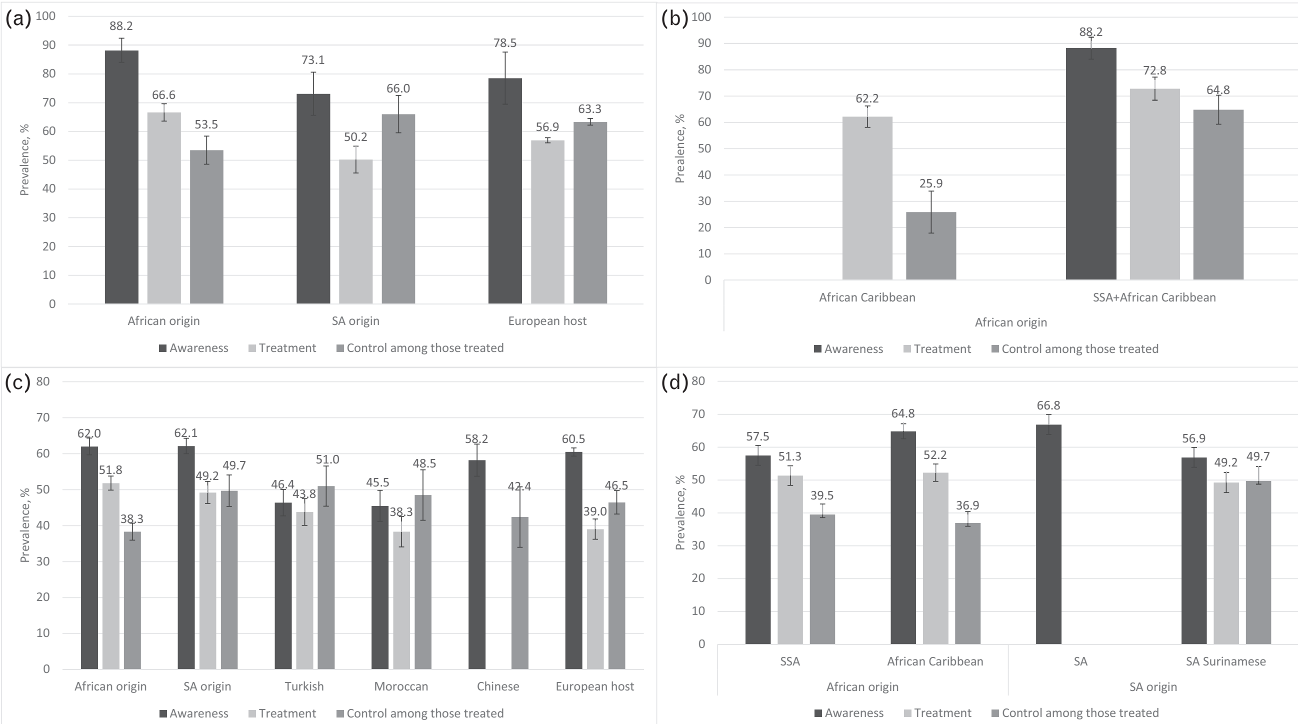

FIGURE 1 Unweighted pooled prevalence rates of hypertension awareness, treatment and control among those on treatment per ethnic population. Panel (a) shows the results of studies using blood pressure cut-offs of systolic at least 160 and/or diastolic at least 95 mmHg to define hypertension; panel (b) shows the pooled prevalence rates for the subpopulations of African origin that were pooled together in panel (a); panel (c) shows the results of studies using blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension; panel (d) shows the pooled prevalence rates for the subpopulations of African origin and South Asian origin that were pooled together in panel (c); error bars are 95% confidence intervals. SA, South Asian; SSA, sub-Saharan Africa.

representation of the national population (e.g. study conducted in urban areas only), the sampling frame was not a close representation of the target population (e.g. sampling frame consisting of general practitioner practices) and/or there was a substantial risk of non-response bias (e.g. no comparison of characteristics between responders and nonresponders was reported). In general, the internal validity of the studies was good, although most older

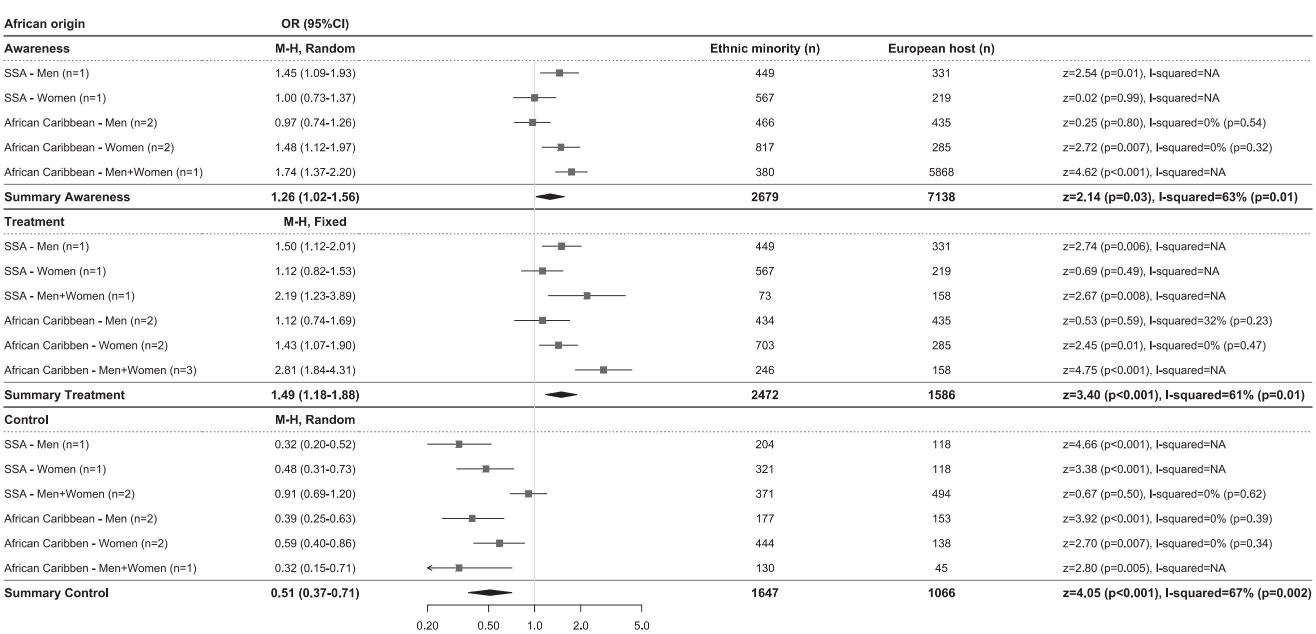

FIGURE 2 Comparison of prevalence of hypertension awareness, treatment and control among those on treatment between African origin and European host populations of studies using blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension. Diamonds denote the weighted pooled odds ratios with 95% confidence intervals. CI, confidence interval; M–H, Mantel–Haenszel; OR, odds ratio; SSA, sub-Saharan African, '*n*' is the number of comparisons available for each subgroup.

South Asian origin	OR (95%CI)	Ethnic minority (n)	European host (n)	
Awareness	**M-H, Fixed**			
SA - Men (n=1)	1.40 (0.67-2.92)	108	54	z=0.89 (p=0.37), I-squared=NA
SA - Women (n=1)	1.86 (0.71-4.88)	73	53	z=1.27 (p=0.21), I-squared=NA
SA - Men+Women n=1)	1.07 (0.92-1.26)	748	5868	z=0.88 (p=0.38), I-squared=NA
SA Surinamse - Men (n=2)	1.18 (0.91-1.54)	491	435	z=1.27 (p=0.21), I-squared=0% (p=0.47)
SA Surinamese - Women (n=2)	1.33 (0.99-1.78)	529	323	z=1.92 (p=0.06), I-squared=87% (p=0.006)
Summary Awareness	**1.15 (1.02-1.30)**	**1949**	**6733**	**z=2.33 (p=0.02), I-squared=44% (p=0.10)**
Treatment	**M-H, Fixed**			
SA Surinamse - Men (n=2)	1.33 (0.54-3.26)	491	435	z=0.62 (p=0.54), I-squared=82% (p=0.02)
SA Surinamese - Women (n=2)	1.15 (0.55-2.43)	529	285	z=0.37 (p=0.71), I-squared=74% (p=0.05)
Summary Treatment	**1.25 (0.72-2.17)**	**1020**	**720**	**z=0.80 (p=0.42), I-squared=83% (p<0.001)**
Control	**M-H, Fixed**			
SA Surinamse - Men (n=2)	0.65 (0.42-0.98)	241	153	z=2.04 (p=0.04), I-squared=0% (p=0.71)
SA Surinamese - Women (n=2)	0.90 (0.59-1.37)	258	138	z=0.49 (p=0.63), I-squared=0 (p=0.58)
Summary Control	**0.76 (0.57-1.03)**	**499**	**291**	**z=1.79 (p=0.07), I-squared=0% (p=0.65)**

0.20 0.50 1.0 2.0 5.0
Favours European host Favours ethnic minority

FIGURE 3 Comparison of prevalence of hypertension awareness, treatment and control among those on treatment between South Asian origin and European host populations of studies using blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension. Diamonds denote the weighted pooled odds ratios with 95% confidence intervals. CI, confidence interval; M–H, Mantel–Haenszel; OR, odds ratio; SA, South Asian, '*n*' is the number of comparisons available for each subgroup.

Turkish	OR (95%CI)	Ethnic minority (n)	European host (n)	
Awareness	**M-H, Fixed**			
Turkish - Men (n=2)	0.65 (0.48-0.86)	374	434	z=2.98 (p=0.003), I-squared=0% (p=1.00)
Turkish - Women (n=2)	1.05 (0.77-1.45)	330	324	z=0.33 (p=0.74), I-squared=0% (p=0.82)
Summary Awareness	**0.81 (0.65-1.00)**	**704**	**758**	**z=2.00 (p=0.05), I-squared=41% (p=0.17)**
Treatment	**M-H, Random**			
Turkish - Men (n=2)	0.75 (0.55-1.02)	374	434	z=1.84 (p=0.07), I-squared=0% (p=0.62)
Turkish - Women (n=2)	1.02 (0.41-2.54)	330	324	z=0.05 (p=0.96), I-squared=82% (p=0.02)
Summary Treatment	**0.88 (0.54-1.41)**	**704**	**758**	**z=0.55 (p=0.58), I-squared=73% (p=0.01)**
Control	**M-H, Fixed**			
Turkish - Men (n=2)	0.77 (0.47-1.29)	107	147	z=0.98 (p=0.33), I-squared=0% (p=0.78)
Turkish - Women (n=2)	0.96 (0.62-1.49)	201	174	z=0.18 (p=0.86), I-squared=47% (p=0.17)
Summary Control	**0.88 (0.63-1.22)**	**308**	**321**	**z=0.78 (p=0.44), I-squared=0% (p=0.53)**

0.20 0.50 1.0 2.0 5.0
Favours European host Favours ethnic minority

FIGURE 4 Comparison of prevalence of hypertension awareness, treatment and control among those on treatment between Turkish and European host populations of studies using blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension. Diamonds denote the weighted pooled odds ratios with 95% confidence intervals. CI, confidence interval; M–H, Mantel–Haenszel; OR, odds ratio, '*n*' is the number of comparisons available for each subgroup.

studies did not report on the calibration of the auscultatory BP measurement (standard or Hawksley random zero sphygmomanometer).

DISCUSSION

In the present systematic review and meta-analysis comparing 26 800 individuals of five different EMPs with 57 000 individuals from the EHP, we show that levels of hypertension awareness, treatment and control significantly differ between EMPs and the EHP. Compared with the EHP, African origin populations had higher rates of hypertension awareness and treatment, but a lower rate of hypertension control; South Asian origin populations had a higher rate of hypertension awareness, but no differences in the rates of hypertension treatment or control; Turkish populations had

Moroccan	OR (95%CI)	Ethnic minority (n)	European host (n)	
Awareness	**M-H, Fixed**			
Moroccan - Men (n=2)	0.77 (0.55-1.06)	258	382	z=1.60 (p=0.11), I-squared=0% (p=0.37)
Moroccan - Women (n=2)	0.81 (0.58-1.14)	248	324	z=1.19 (p=0.23), I-squared=79% (p=0.03)
Summary Awareness	**0.79 (0.62-1.00)**	**506**	**706**	**z=1.98 (p=0.05), I-squared=47% (p=0.13)**
Treatment	**M-H, Fixed**			
Moroccan - Men (n=2)	0.77 (0.55-1.08)	258	434	z=1.49 (p=0.14), I-squared=0% (p=0.97)
Moroccan - Women (n=2)	0.76 (0.54-1.07)	248	324	z=1.58 (p=0.03), I-squared=45% (p=0.14)
Summary Treatment	**0.77 (0.60-0.97)**	**506**	**758**	**z=2.17 (p=0.03), I-squared=45% (p=0.14)**
Control	**M-H, Fixed**			
Moroccan - Men (n=2)	0.90 (0.51-1.59)	74	147	z=0.36 (p=0.72), I-squared=0% (p=0.79)
Moroccan - Women (n=2)	0.69 (0.41-1.15)	120	174	z=1.43 (p=0.15), I-squared=0% (p=0.94)
Summary Control	**0.78 (0.53-1.13)**	**194**	**321**	**z=1.31 (p=0.19), I-squared=0% (p=0.91)**

0.20 0.50 1.0 2.0 5.0
Favours European host Favours ethnic minority

FIGURE 5 Comparison of prevalence of hypertension awareness, treatment and control among those on treatment between Moroccan and European host populations of studies using blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension. Diamonds denote the weighted pooled odds ratios with 95% confidence intervals. CI, confidence interval; M–H, Mantel–Haenszel; OR, odds ratio, '*n*' is the number of comparisons available for each subgroup.

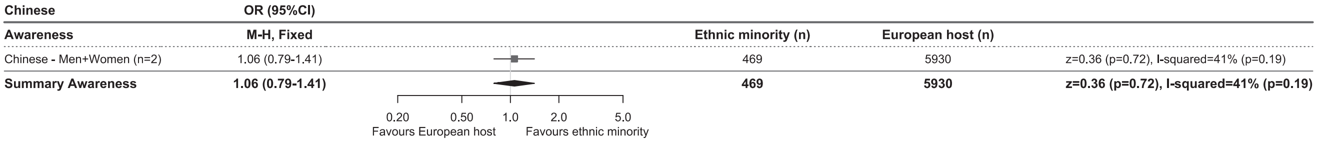

FIGURE 6 Comparison of prevalence of hypertension awareness between Chinese and European host populations of studies using blood pressure cut-offs of systolic at least 140 and/or diastolic at least 90 mmHg to define hypertension. Diamonds denote the weighted pooled odds ratios with 95% confidence intervals. CI, confidence interval; M–H, Mantel–Haenszel; OR, odds ratio, '*n*' is the number of comparisons available for each subgroup.

a lower rate of hypertension awareness, but no differences in treatment and control rates; Moroccan populations had lower rates of hypertension awareness and treatment, but no difference in control rate; Chinese populations did not differ in hypertension awareness rates.

The current findings of higher awareness and treatment in African and South Asian origin populations could be the result of health promotion campaigns specifically targeting these populations because of established higher risk of CVD, emphasizing the importance of regular BP checks and medication adherence [30]. In addition, alertness among healthcare providers might have increased, for instance by introduction of ethnic-specific hypertension treatment recommendations in CVD prevention guidelines [31]. The lower levels of awareness in Turkish and of awareness and treatment in Moroccan populations compared with the host population are of concern. Historically, these populations were considered as having a low CVD risk, because of their adherence to the Mediterranean diet and lower prevalence of hypertension compared with the EHP [27]. However, as trends in coronary heart disease incidence among Turkish and Moroccan populations are changing in an unfavourable direction [32], more BP screening activities should be directed towards these populations.

Remarkably, compared with the EHP, African origin populations had lower hypertension control levels, despite higher levels of hypertension awareness and treatment. In addition to lower levels of awareness and treatment, Turkish men and Moroccan women also tended to have lower hypertension control rates compared with their counterparts from the EHP. Compared the EHPs, included participants from EMPs seemed to be slightly younger, having higher BMI and higher fasting plasma glucose levels, potentially impacting the observed differences in hypertension control rates. Alternatively, differences in (determinants of) access to healthcare between ethnic minority and EHPs, might impact the hypertension control rates of these populations [33]. For instance, from the patient perspective, the ability to seek, to pay for, and to engage in hypertension care are influenced by culture, socioeconomic status and medication adherence, and these factors may differ between populations of different ethnic origin, resulting in differences in hypertension control rates. Results from studies conducted in the USA support this, showing differential contribution of factors to hypertension control between different ethnic groups [34]. In addition, from the healthcare provider perspective, factors like clinical inertia or non-adherence to European medical guidelines in terms of drug prescription could contribute to the ethnic differences in control rates among those patients being on BP-lowering treatment. For instance, despite ethnic-specific hypertension treatment recommendations for patients of African origin, physicians do not always implement this in their medication prescription practices [35]. To improve hypertension control rates, research is needed to identify key factors affecting hypertension control in EMPs of African, Turkish and Moroccan origin, on both patient's and healthcare provider's level, and based on that, targeted interventions should be developed and implemented.

The lower hypertension treatment and control rates in the studies using a low BP threshold (BP $\geq$ 140/90 mmHg) compared with the studies using a high BP cut-off (BP $\geq$ 160/95 mmHg) could be a result of introduction of cardiovascular risk management guidelines [36]. In the Netherlands and the United Kingdom, where most of the included studies originated from, the decision to start treatment for high BP not solely depends on BP cut-offs, but rather on a score based on multiple CVD risk factors [37,38]. Countries adhering to guidelines in which antihypertensive medication initiation does not necessarily depends on CVD risk scores, such as Canada and the USA, report higher rates of hypertension awareness, treatment and control rates than presented in this review [36]. The National Health and Nutrition Survey from the USA reported hypertension awareness, treatment and control rates (using BP cut-off of 140/90 mmHg to define hypertension) for those aged 45–65 years to be 86, 78 and 65% in African-American, and 84, 75 and 78% in White-Americans [8], which are considerably higher than the rates reported for African origin and EHP in this review.

The current review is the first to report aggregated data of population-based studies on hypertension awareness, treatment and control levels among EMPs in Europe, representing four of the five largest ethnic minority groups originating from outside Europe residing in the EU [39], and data from African origin populations.

Risk of bias mainly originated from limitations in the external validity of the included studies, as most of the studies were conducted in populations residing in urban settings, which might not be a close representation of the national population. Rural–urban differences in supply of healthcare services have been described [40], and hypertension prevalence and control rates are known to show intranational differences [41]. However, as migrant populations tend to congregate in cities [42], the data reported in this review are probably representative for the EMPs in these countries. In addition, external validity might be hampered as the sampling frame of most studies consisted of general practices or health centres, hereby excluding individuals that were not registered at these facilities. In the light of EMPs, this sampling frame could have resulted in excluding recently migrated or undocumented migrants, as in many European countries the access to healthcare service depends on the legal status of the immigrants, and is often limited for undocumented migrants to emergency care services only [43]. Therefore, more research is needed into hypertension status of these underserved populations.

Second, included studies were conducted in a limited number of European countries, with most studies originating from the United Kingdom and the Netherlands, hereby hampering the generalizability of our finding to the whole of Europe. To get a comprehensive overview of the hypertension status of EMPs in Europe, primary population-based studies conducted in more European countries are needed. Moreover, to identify and address inequalities in health, future research should take into consideration diversity within migrant populations originating from a shared geographical region (e.g. between African Caribbean and SSA populations), for instance by taking migration history into account and defining ethnicity in a more detailed and consistent way [44].

Third, the results of this review should be interpreted in the light of heterogeneity between studies. For instance, studies used different indicators of ethnicity, included participants from different age ranges, or used a slightly different definition for hypertension control. The limited number of included studies did not allow for sensitivity analysis stratifying for these differences.

Lastly, the included studies diagnosed hypertension based on multiple BP readings taken on a single occasion. Therefore, as BP is highly variable, it is possible that the reported prevalence of hypertension was overestimated, hereby underestimating the levels of hypertension awareness and treatment. However, as these limitations apply both to the minority ethnic groups as well as to the EHPs included in this study, the estimated differences in awareness, treatment and control rates between the minority and the host population remain valid.

The findings from this systematic and meta-analysis show clear differences between ethnic minority and EHPs in terms of hypertension awareness, treatment and control rates. To improve hypertension awareness, treatment and control rates and diminish differences between populations, determinants of these rates should be identified and ethnic-specific intervention strategies should be designed and implemented, ultimately aiming to reduce ethnic inequalities in hypertension-related complications.

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Authors' contributions: E.L.v.d.L., B.-J.H.v.d.B. and C.A. conceived the study. J.G.D. designed the literature search strategy; E.L.v.d.L. and B.N.C. conducted the literature search and data extraction. E.L.v.d.L. performed the statistical analysis and wrote the article, in close collaboration with E.J.A.J.B, B.-J.H.v.d.B and C.A. All authors approved the final version of the article.

Conflicts of interest

There are no conflicts of interest.

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