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REVIEW PAPER

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Screening for hypertension using emergency department blood pressure measurements can identify patients with undiagnosed hypertension: A systematic review with meta-analysis

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Abstract

Hypertension is the leading risk factor for death globally. A significant percentage of patients admitted to hospital have undiagnosed hypertension, yet recognition of elevated blood pressure (BP) in hospital and referral for post-discharge assessment are poor. Physician perception that elevated inhospital BP is attributable to anxiety, pain, or white coat syndrome may underlie an expectation that BP will normalize following discharge. However, these patients frequently remain hypertensive. The authors conducted a systematic review to evaluate the extent to which elevated inhospital BP can predict the presence of hypertension in previously undiagnosed adults. The authors included cohort studies in which hospital patients whose BP exceeded the study threshold underwent further post-discharge BP assessment following discharge. Twelve studies were identified as eligible for inclusion; a total of 2627 participants met review eligibility criteria, and follow-up BP data were available for 1240 (47.2%). Median percentage of patients remaining hypertensive following discharge was 43.6% (range: 14.2-76.5). Across 7 studies which identified people with possible hypertension using an index test threshold of 140/90, the pooled proportion subsequently identified with hypertension at follow-up was 43.4% (95% CI: 25.1%-61.8%). This review indicates that screening for hypertension in the emergency hospital environment consistently identifies groups of patients with undiagnosed hypertension. Unscheduled hospital attendance therefore offers an important public health opportunity to identify patients with undiagnosed hypertension.

1 | INTRODUCTION

1.1 | Background

Hypertension is the leading risk factor for death[1] with 12.8% of annual global mortality attributable to hypertension.[2] More than 40 years ago, it was recognized that patients commonly had elevated blood pressure in hospital, but that follow-up to determine whether they remained hypertensive in the community was poor.[3,4] More recent research suggests that recognition of elevated blood pressure (BP) among patients in hospital continues to be lacking[5] and referral for community follow-up remains poor.[6-9] One reason for this may be the absence of a definition for elevated inhospital BP in the literature and hypertension guidelines. Furthermore, physician perception that elevated inhospital BP is attributable to anxiety,[10] pain,[11] or white coat syndrome[12] may underlie an expectation that elevated BP will normalize following discharge. However, these patients frequently remain hypertensive in the community,[13-18] including when the observed elevated BP occurs in emergency department (ED) triage.[19]

1.2 | Importance

Untreated hypertension is associated with a progressive increase in BP that can become treatment-resistant.[20] Therefore, the hospital setting, in which BP is routinely measured, offers an opportunity for diagnostic screening to address this major cause of morbidity and mortality.[21] Presently, however, guidance on the management of elevated BP in hospital is confined to the ED setting,[22] and there is apparent lack of consensus on management and follow-up of elevated BP for the inpatient setting. Even in the ED setting, the guidelines draw upon evidence from a limited number of studies which have major limitations such as small or unrepresentative cohorts and the authors of these guidelines recommend further research investigating optimal screening and follow-up interval.

1.3 | Goals of this investigation

This systematic review investigates the extent to which elevated inhospital BP measurements can predict the presence of hypertension in adults with no prior hypertensive diagnosis or treatment. The review presents the evidence to date to help inform clinical management of newly detected elevated BP in the hospital setting.

2 | METHODS

The review is reported according to the Preferred Reporting Items for Systematic Review and Meta-Analysis-Diagnostic Test Accuracy (PRISMA-DTA) statement.[23] The protocol for this systematic review was prospectively registered on the International Prospective Register of Systematic Reviews (PROSPERO: registration number: CRD42018095400).

2.1 | Eligibility criteria

Studies relevant to this review were cohort studies in which hospital patients identified with BP exceeding study threshold were followed up post-discharge for further BP assessment. Eligibility criteria for the participant cohort were as follows:

(i) Age ≥18 years
(ii) No pre-existing diagnosis of hypertension
(iii) Attended ED or admitted to hospital
(iv) Reason for index admission not being one of hypertension or hypertension-Related end-organ disease (eg, acute coronary syndrome, acute vascular injury, stroke, or end-stage renal failure)
(v) No BP treatment initiated prior to follow-up BP assessment
(vi) Stratified for post-discharge BP assessment using inhospital BP measurements
(vii) Not pregnant

For inclusion criterion "(ii)," studies were eligible if they included a statement that patients with a history of hypertension and prescribed antihypertensives were excluded. We did not specify the method of exclusion. For inclusion criterion "(v)," studies where all participants were commenced on antihypertensive medications prior to, upon discharge or between discharge and blood pressure follow-up, were excluded. For studies where some, but not all, participants were started on antihypertensive medications at one of these points, those participants who remained without an antihypertensive prescription at blood pressure follow-up were included in the meta-analysis.

2.2 | Search strategy

MEDLINE, EMBASE, and CINAHL databases were searched from inception to May 2018 for cohort studies meeting the above criteria. Search strategies were developed with a medical librarian. We used key terms relating to hospital patients (emergency department, inpatient, hospitalized), follow-up (outpatient, home monitor, community), and BP measurements (blood pressure, ambulatory blood pressure monitoring). Where keywords revealed medical subject headings (MeSH) or index terms respective of database, these were included. Reference lists of identified articles were searched for additional titles. Results were limited to studies of adult populations and published journal articles. Studies published in all languages were eligible. Full search strategies are provided in Appendix S1.

2.3 | Study selection

Two reviewers (LA and MW) independently screened all citations by title and abstract. Any queries or disagreements were adjudicated with a third reviewer (AF). The same reviewers independently screened the full text of selected studies and again any disagreements resolved with the third reviewer. Reference lists of all included full-text articles were screened by the first author (LA) and full text of relevant citations was screened independently by LA and MW for eligibility.

2.4 | Data extraction

A custom data extraction form was piloted with one included study, by two reviewers (LA and MW). Data extraction for the remaining studies was then completed independently by both reviewers and compared for consistency. Any disagreements were resolved with a third reviewer (AF). Authors were contacted for information required but not available in published articles. Study characteristics included country, study design, participant characteristics, and sample size. Data related to the index and follow-up BP assessment included sphygmomanometer type, BP threshold for the index and follow-up assessments, follow-up interval, and setting.

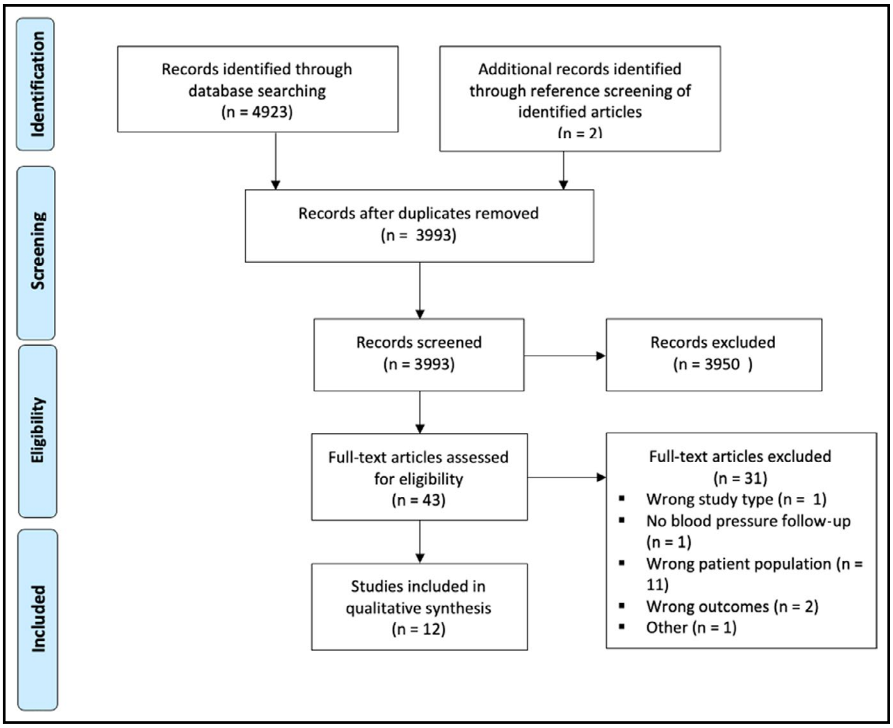

FIGURE 1 The PRISMA flowchart of the study selection

The following outcome data were extracted for each study:

1. Number of patients in each cohort study eligible for inclusion in this review, defined as number of patients in the cohort who (i) had no prior diagnosis of hypertension and (ii) were not prescribed antihypertensive medication prior to follow-up.
2. Number of patients for whom follow-up BP data were available.
3. Number of those diagnosed with hypertension at follow-up
4. Number of those with hypertension at follow-up who commenced treatment.

The percentage diagnosed with hypertension at follow-up was calculated on a per-protocol basis from items 2 and 3. The pooled value for the proportion of individuals subsequently identified with hypertension at a common index threshold of 140/90 mm Hg was calculated using a random effects model in Stata (Version 11.2). Confidence intervals and overall effect size were calculated using the "metaprop" command. Heterogeneity was estimated using the I^2 statistic (range: 0%-100%). We investigated for trends in percentage of patients with hypertension at follow-up against index BP threshold, BP data against which the index threshold was applied and method of follow-up BP assessment.

2.5 | Risk of bias assessment in individual studies

Two reviewers (LA and MW) independently assessed the quality of manuscripts using approaches recommended in the Newcastle-Ottawa Scale assessment tool.[24] The main criteria were as follows: (a) representativeness of cohort; (b) ascertainment of "exposure" (elevated inhospital BP); (c) independent or blind assessment of outcome; (d) demonstration that the outcome of interest (hypertension diagnosis) was not present at study start; (e) suitable follow-up period; and (f) adequacy of follow-up. According to our predefined inclusion criteria, studies were eligible if they made an explicit statement that patients were screened to ensure the outcome of interest (diagnosis of hypertension) was not present at the start of the study. We did not assess the accuracy of screening for pre-existing hypertension as part of the risk of bias assessment; this would not be possible without knowledge of specific study audit practice. None of the 12 included studies had a "non-exposed" comparator group and so were not assessed against comparability items of the Newcastle-Ottawa Scale. Further details outlining the method of assessing risk of bias are provided in Appendix S2. Publication bias could not be assessed owing to lack of comparator groups in the included studies.

3 | RESULTS

The initial electronic database search returned 4923 citations. A further 2 studies were identified from reference lists of identified articles (Figure 1). After removal of duplicates, 3993 citations were screened by title and abstract. Full texts of 43 (1.1%) articles considered potentially eligible were reviewed. Of these, 12 (27.9%) citations met inclusion criteria. Reasons for exclusion are presented; notably, a single study was excluded as only 1/146 study participants met eligibility criteria for this review.[25] Across the 12 included studies, 2627 participants met eligibility criteria for this review. Follow-up BP data were available for 1239 (47.2%) participants.

Study characteristics are presented in Table 1. The lowest mean age of a patient cohort was 43.9 years,[26] and highest mean age was

TABLE 1 Study characteristics

Authors, year	Country	Study design	Participant characteristics at recruitment: Mean age (SD where available)	Ethnicity (%)		Male (%)	Eligibility BP threshold (mm Hg)	Eligible cohort sample size	Number with follow-up data
Chernow et al, 1987	USA	Prospective cohort	49	White	81	52.3	>159 systolic or >94 diastolic	68	68
				Hispanic	17				
				Black	1				
				Other	1				
Slater et al, 1987	UK	Prospective cohort	n/a	n/a		n/a	Single diastolic reading >95	60	53
Backer et al, 2003	USA	Prospective cohort	47	n/a		53.6	≥140 systolic or ≥90 diastolic	405	266
Dieterle et al, 2004	Switzerland	Prospective cohort	60.1 (19.9)	n/a		68.3	≥160 systolic and ≥100 diastolic	45	41
Fleming et al, 2005	UK	Prospective	n/a	n/a		54.9	≥140 systolic or ≥90 diastolic	126	51
Karras et al, 2005	USA	Prospective cross-sectional	51.9	White	11.3	53.7	≥140 systolic or ≥90 diastolic	346	49
				Hispanic	21.7				
				Black	63.1				
				Other	2.6				
Tanabe et al, 2008	USA	Prospective cohort	n/a*	White	62.2	48.1	≥140 systolic or ≥90 diastolic	189	156
				Black	33.3				
				Asian	1.2				
				Other	3.1				
Svenson et al, 2008	USA	Prospective cohort	n/a	n/a		n/a	≥140 systolic or ≥90 diastolic	405	39
Julliard et al, 2012	USA	Prospective cohort	43.9	n/a		67.2	Stage 1 HTN >140 systolic or ≥90 diastolic or Stage 2 HTN ≥160 systolic or ≥100 diastolic	197	17
Tsoi et al, 2012	Hong Kong	Prospective cross-sectional	52 (15)	Chinese	100	56.6	systolic >140 and <180 or diastolic >90 and <120	245	136
Dolatabadi et al, 2014	Iran	Prospective cross-sectional	46.7 (12.4)	n/a		65.9	≥140 systolic or ≥90 diastolic	346	168
Shiber-Ofer et al, 2015	Israel	Prospective cohort	49.7(12.7)	n/a		52.3	≥140 systolic or ≥90 diastolic	195	195
							TOTAL	2627	1239

Abbreviations: BP, blood pressure; n/a, data not available; SD, standard deviation; UK, United Kingdom; USA, United States of America.
*Unknown for whole cohort. Mean age for those with normal and high blood pressure at follow-up was 44 and 51 y, respectively. All figures given to 1 decimal place where available.

TABLE 2 Quality assessment

Author, year	Representativeness of cohort	Ascertainment of "exposure"	Demonstration that outcome of interest not present at start	Independent assessment of outcome	Suitable follow-up period	Adequacy of cohort follow-up	Conclusions
Chernow et al, 1987							High
Slater et al, 1987					n/a		Intermediate
Backer et al, 2003							High
Dieterle et al, 2004							Low
Fleming et al, 2005							High
Karras et al, 2005							High
Tanabe et al, 2008							Low
Svenson et al, 2008							High
Julliard et al, 2012							High
Tsoi et al, 2012							High
Dolatabadi et al, 2014							High
Shiber-Ofer et al, 2015							Low

Note: n/a = data not available (assessment not possible).

60.1 years.[27] Mean age was neither reported nor available from authors for 3 studies.[10,28,29] In all studies, identification of eligible patients and study recruitment took place in the ED; no studies recruited patients from an inpatient setting.

Of the 12 included studies, 6 were conducted in the United States, 2 in the United Kingdom, and 1 in each of Switzerland, Hong Kong, Israel, and Iran. Three studies reported data on ethnicity,[10,30,31] and authors of 1 study provided data on ethnicity.[32]

3.1 | Risk of bias

The risk of bias assessment for all studies is demonstrated in Table 2. Cohorts in eleven of the 12 studies were deemed truly representative of the average in the community; one study excluded patients with an arm circumference <19 cm or >45 cm and was therefore considered somewhat representative.[33] Overall, 3 studies were considered at low risk of bias,[10,34,35] 1 at intermediate risk of bias,[27] and 8 at high risk of bias.[19,26,28-33] One study screened patients for a pre-existing diagnosis of hypertension through review of medical records, blood pressure measurements of previous hospital attendance, and prescription records[34]; 4 studies screened through a review of notes and patient self-report[11,19,30,31]; 2 studies screened through review of medical records only[27,28]; 1 study screened through patient self-report only[33]; and 4 studies did not report how patients were screened for a pre-existing diagnosis of, or medication prescription for, hypertension.[26,32,35,36]

3.2 | Blood pressure thresholds used for index and follow-up assessment

Details of index and follow-up BP assessments for each study are shown in Table 3. The location of index BP testing was the ED in all studies. The most common index BP threshold utilized was ≥140 mm Hg systolic or ≥90 mm Hg diastolic (also the lowest threshold).[10,19,26,28,29,31-34] No studies were identified in which separate index BP thresholds were applied for night versus daytime. The method of index BP assessment varied between studies, from a single measurement,[31] to half or more of all ED triage measurements required to exceed the index threshold.[26] The most common method of BP assessment at follow-up was clinician-measured BP in either primary[26,27,31,32,34,35] or secondary[19,28,30,33] care clinics. One study used patient-performed home BP monitoring.[10] Two studies collected daytime ambulatory BP monitoring data where possible.[34,35]

Post-discharge follow-up intervals ranged from 1 week[10,35] to 30.14 (±15.96) months.[34] Median time to follow-up was 1 month. Six studies (50%) reported the blood pressure follow-up interval as the maximal time period to follow-up among all participants.[19,26,28,30-32] Nine studies (75%) performed follow-up by prospective review of patient notes (record linkage).[19,26-29,33-35] Three studies (25%) had notably low rates of available follow-up BP data (<20%).[26,28,31]

3.3 | Proportion of patients identified as hypertensive at follow-up

The principal diagnostic accuracy measure reported by studies was the number of patients recorded as having elevated BP (as defined by the study's diagnostic threshold for hypertension) or a recorded diagnosis of hypertension at follow-up. Outcome data for all studies are displayed in Table 4. The median percentage of patients identified as hypertensive at follow-up was 43.6% (range: 14.2-76.5). Across the 7 studies which used a common index BP threshold of 140/90, the pooled proportion of people identified with hypertension at follow-up was 43.4% (95% CI: 25.1%-61.8%; Figure 2). The I^2 measure of heterogeneity between studies was high, at 97.3% (P < .001).

There were no trends in the proportion of participants identified as having hypertension at follow-up when studies were compared

TABLE 3 Index test and reference standard tests

	Index test				Reference test			
Authors, year	Sphygmomano-meter type	Blood pressure threshold	BP measurements evaluated against threshold	Follow-up interval	Sphygmomano-meter type	Blood pressure threshold	BP measurements evaluated against reference threshold	Follow-up blood pressure measurement setting
Chernow et al, 1987	Mercury	>159 systolic or >94 diastolic	Triage and discharge measurements	≤6 wk	n/a	≥140 systolic or >90 diastolic	Office BP	Outpatient clinic (patient self-report of this)
Slater et al, 1987	n/a	Single diastolic reading >95	Single measurement	n/a	n/a	n/a	Office BP	Primary care
Backer et al, 2003	Automated	≥140 systolic or ≥90 diastolic	First measurement	≤6 mo	n/a	≥140 systolic or ≥90 diastolic	Maximum of 2 office BP measurements	Outpatient clinic
Dieterle et al, 2004	Mercury	≥165 systolic and ≥105 diastolic	Mean ABPM taken at 5-min intervals between 60 and 80 min after entry to ED.	1 wk	Automated ABPM or n/a	ABPM: ≥135 systolic or ≥85 diastolic Office BP: ≥140 systolic or ≥90 diastolic	12 h of ABPM at 20 min intervals or office BP in primary care	ABPM or primary care
Fleming et al, 2005	Mercury	≥140 systolic or ≥90 diastolic	Mean of 2 measurements taken 2 min apart	12.4 d (5-23)	Mercury	≥140 systolic or ≥90 diastolic	Last of 3 office BPs taken 2 min apart	Non-acute ED
Karras et al, 2005	Variable	≥140 systolic or ≥90 diastolic	Single measurement	≤3 wk	n/a	n/a	Office BP	Primary care
Tanabe et al, 2008	n/a	≥140 systolic or ≥90 diastolic	2 consecutive measurements	1 wk[a]	Automated	≥140 systolic or ≥90 diastolic (≥130 systolic or ≥80 diastolic if DM)	Mean home BP (after excluding highest and lowest readings)	HBPM: 2 measurements per day
Svenson et al, 2008	n/a	≥140 systolic or ≥90 diastolic	Last recorded measurement	≤4 mo	n/a	n/a	Office BP	Outpatient clinic
Julliard et al, 2012	n/a	Stage 1 HTN >140 systolic or ≥90 diastolic or Stage 2 HTN ≥160 systolic or ≥100 diastolic	Half or more of all (maximum 5) triage blood pressure measurements	≤3 mo	n/a	n/a, based on diagnostic code in medical record	Office BP	Primary care
Tsoi et al, 2012	n/a	systolic >140 and <180 or diastolic >90 and <120	Triage and discharge measurements	≤2 wk	n/a	n/a	Office BP	Primary care

(Continues)

TABLE 3 (Continued)

Authors, year	Index test: Sphygmomanometer type	Index test: Blood pressure threshold	Index test: BP measurements evaluated against threshold	Follow-up interval	Reference test: Sphygmomanometer type	Reference test: Blood pressure threshold	Reference test: BP measurements evaluated against reference threshold	Follow-up blood pressure measurement setting
Dolatabadi et al, 2014	Mercury	≥140 systolic or ≥90 diastolic	2 consecutive measurements taken 10 min apart	1 mo	Mercury	≥140 systolic or ≥90 diastolic	Office BP	Outpatient clinic
Shiber-Ofer et al, 2015	Automated	≥140 systolic or ≥90 diastolic	2 consecutive measurements taken 5 min apart	30.14 mo (±15.96)	Automated ABPM or n/a	Office BP values>/-140/90, mean ABPM >135/85 or anti-hypertensive medications commenced	ABPM or office BP	Primary care or outpatient clinic

Abbreviations: ABPM, ambulatory blood pressure monitoring; BP, blood pressure; d, days; HBPM, home blood pressure monitoring; mo, months; n/a, data not available; wk, weeks.

[a]Blood pressure was monitored at home for 1 wk.

on index BP threshold, BP data against which the threshold was applied, or method of outcome assessment (self-report, record linkage, or independent BP assessment; see Table S1-S3). It was not possible to perform statistical analysis of outcome measure according to ethnicity, owing to small sample sizes and small number of studies reporting ethnicity. However, it was noted that the two studies in which the majority of the cohort were white, reported follow-up hypertension rates of 50.6%[10] and 62%[30] and those studies in which the majority of the cohort were of a non-white ethnic group reported lower follow-up hypertension rates of 14.3%[31] and 35.3%.[32]

4 | DISCUSSION

4.1 | Summary of evidence

This review of diagnostic studies aimed to evaluate the extent to which elevated inhospital BP measurements can predict the presence of undiagnosed hypertension. We identified twelve studies which investigated this question within the emergency department population, but none in the inpatient population. The lowest index BP threshold identified among these studies was 140 mm Hg systolic or 90 mm Hg diastolic. All studies identified a proportion of patients with hypertension at follow-up; excluding studies with <20% follow-up, post-discharge diagnosis of hypertension occurred in around 25% or more participants. Among studies assessed as being at low risk of bias, post-discharge diagnosis of hypertension occurred in over 50% of participants (range: 50.6%[7]-72.3%[34]). This consistent identification of undiagnosed hypertensive patients demonstrates the potential clinical benefit of utilizing hospital attendance to screen for undiagnosed hypertension.

Despite consistent identification of people with hypertension among the included studies, there was marked variability in reported prevalence between studies (range: 14.3%-76.5%; 24.8%-76.5% when low follow-up rate studies are excluded). Variability could not be accounted for by index BP threshold, BP measurements against which index thresholds were applied, or method of follow-up BP assessment (Tables S1-S3). It is possible this variability is attributable to heterogeneity between studies including cohort demographics and methodology (eg, index and follow-up BP assessments, and follow-up interval).

All studies performed index BP assessments in the ED, with no studies utilizing inpatient hospital data. This may, in part, explain the lack of guidance on the management of inpatient hypertension. Of the 12 studies, 11 used routinely collected BP measurements from ED to identify potential participants.[7,19,26-28,30-33,35] Six used these measurements for the index BP assessment,[19,26-28,31,32] while five reassessed BP through additional measurements in ED.[7,30,33-35] One study did not use routinely collected BP for screening and performed BP screening measurements independent of usual observations made in ED.[29]

Most studies used international thresholds (≥140 mm Hg systolic or ≥90 mm Hg diastolic) to diagnose hypertension at follow-up. However, follow-up methodology varied by setting (home,

TABLE 4 Follow-up outcome data

Author, year	Index blood pressure threshold	Eligible cohort number	Number (%) with available follow-up blood pressure	Number (%) of those with elevated follow-up BP	Percentage (n) commenced on treatment at follow-up
Chernow et al, 1987	>159 systolic or >94 diastolic	68	68 (100)	42 (62)	43 (18)[a]
Slater et al, 1987	Single diastolic reading >95	60	53 (88)	15 (28)	93.3 (14)
Backer et al, 2003	≥140 systolic or ≥90 diastolic	405	266 (67)	66 (25)	n/a
Dieterle et al, 2004	≥165 systolic and ≥105 diastolic	45	41 (91)	26 (63)	n/a
Fleming et al, 2005	≥140 systolic or ≥90 diastolic	126	51 (40)	39 (76)	n/a
Karras et al, 2005	≥140 systolic or ≥90 diastolic	346	49 (14)	7 (14)	n/a
Tanabe et al, 2008	≥140 systolic or ≥90 diastolic	189	156 (83)	79 (51)	n/a
Svenson et al, 2008	≥140 systolic or ≥90 diastolic	405	39 (10)	17 (44)	n/a
Julliard et al, 2012	Stage 1 HTN >140 systolic or ≥90 diastolic or Stage 2 HTN ≥160 systolic or ≥100 diastolic	197	17 (9)	5 (29)	40 (2)
Tsoi et al, 2012	systolic >140 and <180 or diastolic >90 and <120	245	136 (56)	48 (35)	91.7 (44)
Dolatabadi et al, 2014	≥140 systolic or ≥90 diastolic	346	168 (49)	48 (29)	n/a[b]
Shiber-Ofer et al, 2015	≥140 systolic or ≥90 diastolic	195	195 (100)	142 (73)	91.5 (130)

Abbreviations: BP, blood pressure; HTN, hypertension; n/a, not applicable.

[a]Article states all 48 participants identified as hypertensive at follow-up were referred to an internist for treatment.

[b]Treatment included either starting medication, dietary changes, or initiating a "hypertension workup".

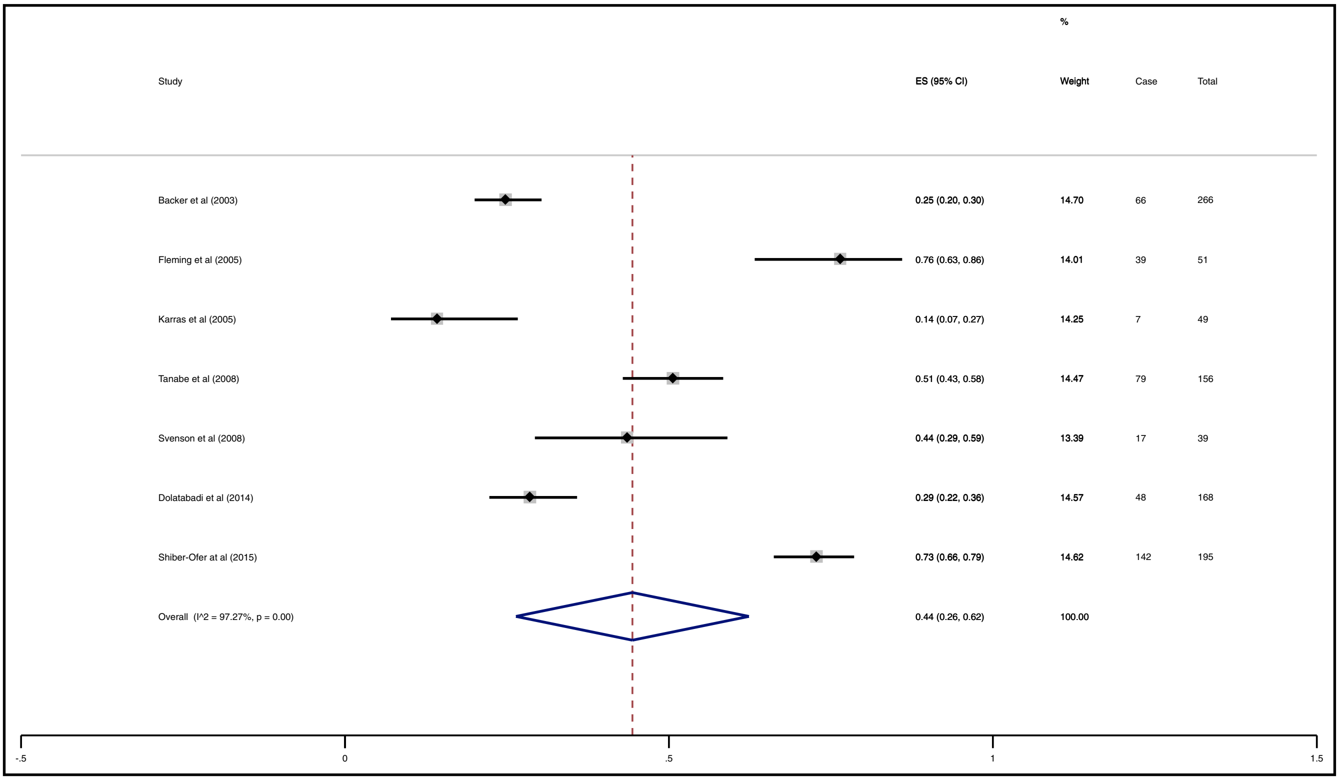

FIGURE 2 Forest plot demonstrating the pooled proportion of people across the seven studies who were identified with possible hypertension at the index test using a detection threshold of 140/90 and who were subsequently identified with hypertension

ambulatory, or office), method of BP data collection (record linkage, participant self-report, measured by research personnel), and follow-up interval. While recent American guidelines for hypertension present values of equivalence according to setting, the varying methods of BP follow-up seen in the included studies mean some caution are required in comparing proportions of patients subsequently diagnosed with hypertension between these studies.

It has been reported previously that referral for follow-up assessment of patients identified with elevated inhospital BP is lacking.[21] Underlying reasons may include physician perceptions regarding causes of elevated inhospital BP[11] and the lack of evidence on further management of elevated inhospital BP in the nonemergency setting.[20,37,38] Our review highlights the need for research to be undertaken on patients with inhospital hypertension.

4.2 | Strengths and limitations at study and outcome level

This review of diagnostic studies is limited by studies either not collecting or reporting data which could be used to calculate sensitivity and specificity for index BP thresholds. In addition, interpretation of the pooled analysis of proportions among the 7 studies sharing a common index BP threshold is necessarily cautious due to heterogeneity between these studies. Some of this heterogeneity will result from fundamental differences in study design between the included studies. Therefore, questions remain regarding the appropriately sensitive and specific inhospital BP thresholds against which patients may be screened for undiagnosed hypertension. Additional high-quality research is needed in this field to establish the optimal methodology for index BP assessment, including index BP threshold.

Differences between reference standard tests for hypertension between the studies also limit the comparability of results, and most studies did not use ambulatory blood pressure monitoring for the reference standard. Though this may be considered the gold standard method, recently published guidelines and the wider literature appear to be steering away from the requirement of ambulatory monitoring for a diagnosis of hypertension.[37,39] However, the methods of blood pressure measurement seen in the included studies may reflect "real world" rather than "gold standard" practice. As a result, interpretations of these results may still be meaningful in normal clinical practice.

4.3 | Strengths and limitations at review level

This review was conducted according to the registered PROSPERO protocol.[40] Studies of all languages were eligible, and included studies were conducted in a variety of countries. Databases were searched from inception, adding to the comprehensive nature of the review; publication dates ranged from 1987 to 2016. However, inclusion of older studies meant authors could not be contacted to obtain older data or that data had sometimes been destroyed. Risk of bias was assessed using a well-established tool for cohort studies; however, the applicability of a formal assessment of bias in the context of single-group observational studies is limited.

The high degree of heterogeneity between studies means our estimate of the overall incidence of community hypertension following raised emergency department readings should be interpreted cautiously. Meta-regression or subgroup analysis for sources of heterogeneity would not have been appropriate owing to small number of studies and all studies differing from each other on more than one point of methodology. However, all studies showed a substantial incidence of hypertension in the community once it had been identified in the emergency department setting.

5 | CONCLUSIONS

This review of 12 studies has demonstrated that hypertension screening in the acute hospital setting consistently identifies groups of patients with undiagnosed hypertension. Unscheduled hospital attendance therefore offers an important public health opportunity to identify patients with undiagnosed hypertension and has potential to reduce patient burden attributed to the major morbidities and mortality associated with hypertension. However, we were unable to identify any studies of hospital inpatients and found notable differences in reported rates of hypertension at follow-up, likely due to marked variation in methodology. This highlights the need for further research involving hospital inpatients and a consistent and systematic methodology for screening and follow-up assessment.

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CONFLICT OF INTEREST

None to declare.

AUTHOR CONTRIBUTIONS

AF, LA, and PW designed the review. LA and AF undertook methodological planning. LA undertook and refined the searches in consultation with a medical librarian. LA and MW performed initial screening and data extraction, and AF and PW gave screening advice where any disagreements arose. AF undertook the meta-analysis, and all authors contributed to data interpretation. LA led the writing, and all authors contributed to successive drafts and approved the final manuscript.

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SUPPORTING INFORMATION

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

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