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Prevalence of Masked Hypertension among Healthcare Workers: A Systematic Review and Meta-analysis of Ambulatory Blood Pressure Monitoring Studies

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ABSTRACT: Context: Healthcare workers experience shift work, sleep disruption and occupational stress, yet the burden of masked hypertension—normal office blood pressure with elevated out-of-office blood pressure—has not been synthesised. Objective: To estimate the prevalence of masked hypertension among healthcare workers and examine sources of variation. Evidence Acquisition: PubMed/MEDLINE and Europe PMC were searched from inception to 27 August 2026, supplemented by citation and targeted journal searching. Studies were eligible when healthcare personnel underwent paired office and ambulatory or home blood pressure measurement and reported a masked-hypertension numerator and denominator. Study quality was appraised using the JBI prevalence checklist. Proportions were pooled on the logit scale using a restricted maximum-likelihood random-effects model with Hartung–Knapp confidence intervals. Results: Six studies from Spain, the United States, Brazil and India included 1,325 participants and 244 masked-hypertension cases. Study estimates ranged from 8.7 to 23.9 per cent. Pooled prevalence was 17.1 per cent (95% confidence interval 11.3–25.1; I^2=83.4%), with a 95% prediction interval of 5.5–42.4 per cent. Restriction to full 24-hour monitoring yielded 16.7 per cent (9.6–27.4). Shift work was associated with masked hypertension in two studies. Risk of bias was low-to-moderate in one study and moderate-to-high in five. Conclusions: Masked hypertension may affect about one in six healthcare workers in the available study samples. The estimate is not globally representative; heterogeneous definitions, selected samples and sparse regional coverage

support targeted out-of-office confirmation rather than universal ambulatory screening.

INTRODUCTION

Hypertension is a leading modifiable cause of cardiovascular and renal disease. In 2024, an estimated 1.4 billion adults aged 30–79 years were living with hypertension worldwide, and approximately 44 per cent were unaware of the condition.[1] A clinic measurement alone cannot identify every clinically important blood pressure phenotype. Masked hypertension describes non-elevated office blood pressure with elevated out-of-office pressure in a person not taking antihypertensive medication.[2] Its cardiovascular risk is greater than that of sustained normotension and approaches the risk associated with sustained hypertension.[3]

Ambulatory blood pressure monitoring (ABPM) captures blood pressure during work, daily activity and sleep, while home blood pressure monitoring (HBPM) provides repeated measurements over several days. Both can reveal masked hypertension, although they do not identify identical phenotypes.[4] This distinction is especially relevant to healthcare workers, whose clinic measurements may be obtained during a relatively quiet interval while their usual work includes rotating shifts, sustained vigilance, irregular meals, sleep restriction and emotionally demanding care. Night work can blunt normal sleep-related blood pressure dipping, and shift schedules are associated with small increases in blood pressure at population level.[5,6]

Individual studies have reported masked hypertension in healthcare workers, nurses and resident doctors, but their sampling frames and out-of-office measurement protocols differ. A pooled estimate could inform occupational-health screening while making the uncertainty explicit. We therefore reviewed the available evidence to estimate the prevalence of masked hypertension among healthcare workers, assess heterogeneity and describe occupational correlates.

MATERIALS & METHODS

Protocol and reporting: The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement.[7] The protocol was not prospectively registered; this is reported as a methodological limitation and no registration number is claimed.

Search strategy: PubMed/MEDLINE and Europe PMC were searched from inception to 27 August 2026, without date or language restrictions. The PubMed concept set was: ("masked hypertension" OR "masked hypertensive") AND ("health personnel" OR "healthcare worker" OR "health care worker" OR nurse* OR physician* OR doctor* OR resident* OR "hospital employee" OR "medical staff"). Equivalent title-and-abstract terms were used in Europe PMC. References and citing reports of eligible studies were checked, and targeted searches of journal websites were used to locate non-indexed reports. Search results were deduplicated by digital object identifier and normalised title. All cited sources can be consulted without institutional credentials; one included study contributed data from its freely accessible indexed abstract, while the remaining included reports had freely accessible full text.

Eligibility and selection: Cross-sectional and cohort studies were eligible if participants were adult healthcare personnel or healthcare trainees in a clinical institution; office blood pressure was paired with ABPM or HBPM; the authors defined masked hypertension; and an event count and analytic denominator were reported or could be recovered unambiguously from a reported percentage. Studies of treated masked uncontrolled hypertension, patient populations, non-healthcare workforces, case series and reports without a separable healthcare sample were excluded. Reports from the same cohort were linked and the most complete report retained. Screening was conducted in two passes; all full-text decisions and extracted numbers were rechecked against the source record.

Data extraction and outcome definition: A standardised form captured country, setting, profession, sampling method, sample size, age, sex, office technique, out-of-office protocol, diagnostic thresholds, masked-hypertension events and reported correlates. The primary outcome was the proportion with untreated masked hypertension in each study's analytic cohort. Most reports used office blood pressure below 140/90 mmHg and elevated daytime ABPM of at least 135/85 mmHg; some also classified elevated 24-hour or night-time pressure. One study used work-shift rather than full 24-hour ABPM. Where a numerator was not printed, it was back-calculated from the sample size and percentage and accepted only when one integer reproduced the reported percentage.

Risk of bias: The nine-domain JBI checklist for prevalence studies was used to examine the sampling frame and method, sample size, description of participants and setting, sample coverage, validity and consistency of measurement, statistical analysis and response.[8] Domain judgements were recorded as yes, no or unclear; overall categories reflected the likely effect of limitations rather than a mechanical numerical score.

Statistical analysis: Study proportions received exact Clopper–Pearson 95 per cent confidence intervals. For pooling, proportions were transformed to logits and combined with a restricted maximum-likelihood random-effects model. Hartung–Knapp adjustment was used for the pooled 95 per cent confidence interval because few studies were available. Heterogeneity was described by Cochran's Q, I^2 and between-study variance (τ^2); a 95 per cent prediction interval was calculated using a t distribution with $k-2$ degrees of freedom. Planned sensitivity analysis retained only full 24-hour ABPM. Post hoc analyses excluded studies restricted at enrolment to untreated office-normal workers, excluded the mixed study that included undergraduate trainees, and compared Indian with non-Indian studies descriptively. Small-study-effect tests were not performed because fewer than 10 studies were available. Analyses used Python 3.12, NumPy 2.3.5 and SciPy 1.17.0; figures were deterministic outputs from the extracted aggregate data.

RESULTS

Study selection: Database searching identified 126 records and six additional records were located by other methods. After 23 duplicates were removed, 109 titles and abstracts were screened. Eight full-text reports were assessed; a duplicate conference abstract and one report without a paired masked-hypertension event count were excluded. Six studies entered the qualitative and quantitative syntheses (Figure 1).[9–14]

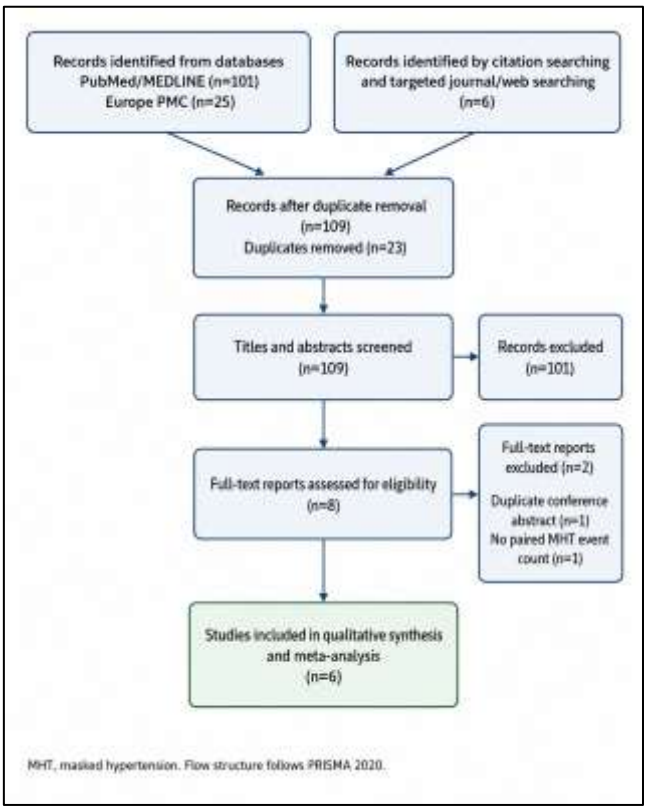

Figure 1: PRISMA 2020 flow diagram for study identification and selection. MHT, masked hypertension.

Study characteristics: The six cross-sectional studies were published between 2013 and 2026 and represented Spain, the United States, Brazil and India (Table I). Participants included mixed hospital and home-care employees, nursing professionals, resident doctors and a mixed healthcare/training cohort. Sample sizes ranged from 89 to 485. Five studies used 24-hour ABPM; the United States study measured work-shift pressure and required at least five work readings. No eligible

HBPM-only study was identified. Two studies restricted the analytic sample to untreated workers with normal office pressure, whereas the other reports classified phenotypes within a broader enrolled cohort.

Table I. Characteristics of the included studies**.**

Study; setting	Participants	Out-of-office method and definition	MHT, n/N (%)	Reported correlates	Risk
Sobrino et al., 2013; 52 hypertension units, Spain	Healthcare workers; mean 43.1 y; 55% women; office-normal untreated sample	24-h ABPM; daytime ≥135/85 with office <140/90 mmHg	116/485 (23.9)	Male sex; high-normal office BP	Moderate
Landsbergis et al., 2013; hospital/home care, New York, USA	110 eligible of 164 workers; 77% women; volunteer sample	Work-shift ABPM; work ≥135/85 with casual <140/90 mmHg; no treatment	21/110 (19.1)	Shift work; job strain plus effort–reward imbalance; age	High
Santos et al., 2023; oncology institute, Rio de Janeiro, Brazil	182 nursing professionals; mean 38.0 y; 82% women; random staff sample	24-h ABPM; daytime ≥135/85 with office ≤140/90 mmHg; no treatment	36/182 (19.8)	Age; shift work	Low–moderate
Sawlani, 2025; tertiary hospital, Lucknow, India	159 resident doctors; mean 27.9 y; 27% women	24-h ABPM; 24-h >130/80, daytime >135/85 or night >120/70 with office ≤140/90 mmHg	34/159 (21.4)	More cases in clinical departments; long hours and short sleep linked to BP/non-dipping	Moderate
Agarwal et al., 2025; medical college, Jhansi, India	300 healthcare personnel/trainees; mean 27.0 y; 39% women; 18% undergraduates	24-h ABPM; elevated 24-h, daytime or night-time BP with normal office BP; numerical ambulatory thresholds incompletely reported	26/300 (8.7)	Not modelled for MHT	High
Upadhyay et al., 2026; tertiary hospital, Dehradun, India	89 resident doctors; age 24–42 y; 36% women; volunteers	24-h ABPM; 24-h >130/80, daytime >135/85 or night >120/70 with office ≤140/90 mmHg	11/89 (12.4)	No association with sex or clinical department	High

ABPM, ambulatory blood pressure monitoring; BP, blood pressure; MHT, masked hypertension. Event counts for Sobrino and Santos were back-calculated from reported percentages. Risk refers to the overall JBI judgement.

Prevalence and heterogeneity: Across studies, 244 of 1,325 participants were classified as having masked hypertension. Individual estimates ranged from 8.7 per cent in a mixed Indian healthcare/training cohort to 23.9 per cent among office-normotensive Spanish healthcare workers. The random-effects pooled prevalence was 17.1 per cent (95% confidence interval 11.3–25.1; Figure 2). Heterogeneity was substantial ($Q=30.05$, $P<0.001$; $I^2=83.4\%$; $\tau^2=0.173$), and the 95 per cent prediction interval was 5.5–42.4 per cent.

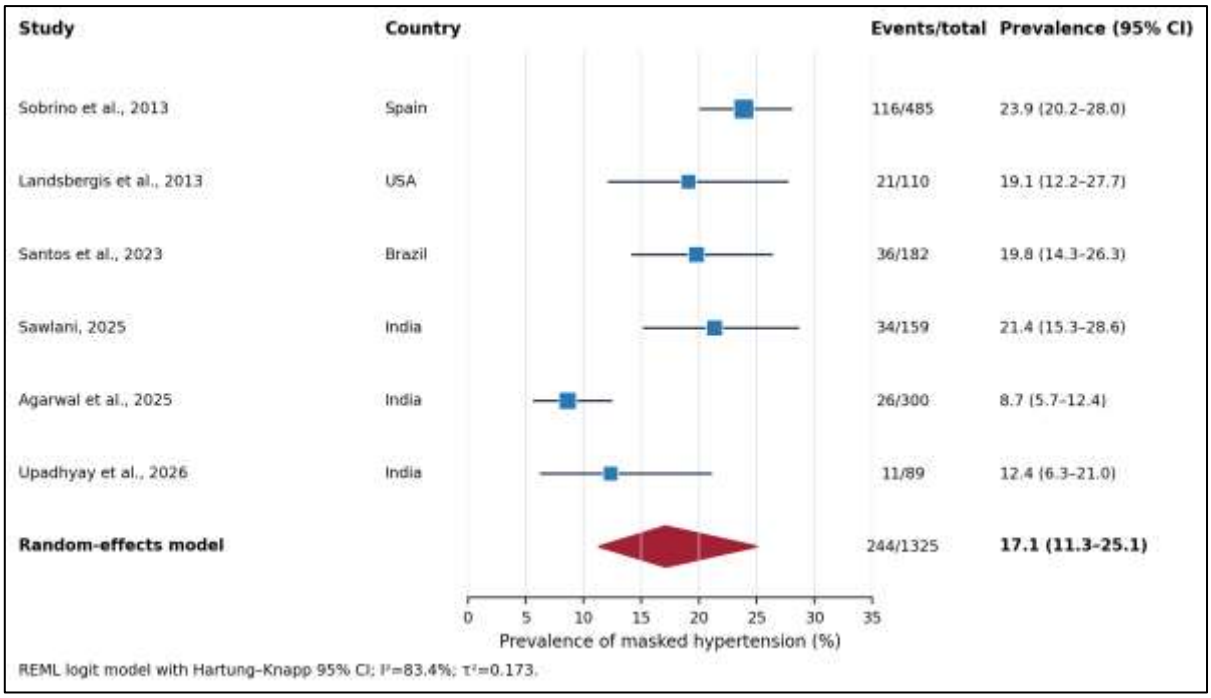

Figure 2: Forest plot of masked-hypertension prevalence. Squares show study estimates with exact 95% confidence intervals; the diamond shows the restricted maximum-likelihood random-effects estimate with Hartung–Knapp confidence interval.

Sensitivity and exploratory analyses: Restricting the analysis to five full 24-hour ABPM studies yielded 16.7 per cent (95% confidence interval 9.6–27.4; $I^2=86.7\%$). Excluding the two samples selected for untreated normal office pressure gave 14.9 per cent (7.3–28.1), while excluding the mixed cohort containing undergraduate trainees gave 20.6 per cent (16.0–26.1; $I^2=39.6\%$). The pooled estimate was 13.4 per cent in three Indian studies and 22.0 per cent in three non-Indian studies; these post hoc comparisons are confounded by study design and period and should not be interpreted as regional effects (Table II).

Table II. Sensitivity and exploratory meta-analyses.

Analysis	Studies	Participants	Pooled prevalence, % (95% CI)	95% prediction interval, %	I^2, %
Primary	6	1,325	17.1 (11.3–25.1)	5.5–42.4	83.4
Full 24-h ABPM only	5	1,215	16.7 (9.6–27.4)	3.7–51.3	86.7
Exclude office-normal selected samples	4	730	14.9 (7.3–28.1)	1.8–62.6	83.0

Analysis	Studies	Participants	Pooled prevalence, % (95% CI)	95% prediction interval, %	I^2, %
Exclude mixed cohort with undergraduates	5	1,025	20.6 (16.0–26.1)	12.9–31.2	39.6
India (exploratory)	3	548	13.4 (3.8–37.7)	Not estimated	85.9
Non-India (exploratory)	3	777	22.0 (16.0–29.5)	Not estimated	2.4

ABPM, ambulatory blood pressure monitoring; CI, confidence interval. Prediction intervals use t with k−2 degrees of freedom and were not estimated for the three-study regional subsets. Regional analyses are post hoc and descriptive.

Associated factors and risk of bias: Male sex and high-normal office pressure were associated with masked hypertension in the Spanish study. Shift work showed strong associations in the United States study (age-adjusted odds ratio 8.25, 95% confidence interval 2.11–40.31) and the Brazilian nursing study (adjusted prevalence ratio 2.18, 1.10–4.31); older age was also associated in both. These estimates were observational and imprecise. The Brazilian study used a random staff list and an a priori sample-size calculation and had the lowest risk of bias. Volunteer or single-centre sampling, unclear response, incomplete reporting of device validation and inconsistent analytic denominators produced moderate-to-high concerns in the other studies (Table III).

Table III. Risk-of-bias assessment using the JBI prevalence-study domains**.**

Study	Sampling frame/method	Sample size	Participant/setting detail	BP measurement validity	Analysis/coverage	Response	Overall
Sobrino 2013	U	Y	Y	Y	Y	U	Moderate
Landsbergis 2013	N	U	Y	U	Y	U	High
Santos 2023	Y	Y	Y	Y	Y	U	Low–moderate
Sawlani 2025	U	Y	Y	Y	Y	U	Moderate
Agarwal 2025	N	Y	Y	U	Y	U	High
Upadhyay 2026	N	N	Y	U	Y	U	High

Y, yes (low concern); N, no (high concern); U, unclear. The sampling column combines the JBI sampling-frame and sampling-method domains; measurement combines valid case identification and consistent measurement; analysis combines sample coverage and appropriate analysis.

DISCUSSION

This synthesis suggests that masked hypertension affects approximately one in six participants in the available healthcare-worker samples. That summary is clinically important because affected workers would appear normotensive in routine office screening, yet it is not a universal or global prevalence estimate. The wide prediction interval and high I^2 show that a new setting could plausibly produce a materially lower or higher estimate.

The pooled value is broadly compatible with population studies: masked hypertension was estimated in 12.3 per cent of United States adults with non-elevated clinic pressure and 16.2 per cent in a Korean population survey using 24-hour ABPM.[15,16] Healthcare-specific excess risk therefore cannot be inferred from this review. The non-Indian studies showed a higher descriptive estimate than the Indian studies, but the contrast largely reflected an older Spanish office-normal sample and a recent mixed Indian cohort with a low estimate. Profession, age, sex, diagnostic threshold, denominator and publication period could not be separated.

The occupational signal was most consistent for shift work. Both studies that modelled it reported an association with masked hypertension, and mechanistic evidence links night work and sleep restriction with sympathetic activation and blunted blood pressure dipping.[5,6] Nevertheless, cross-sectional designs cannot determine whether shift exposure caused the phenotype. Unmeasured factors—including body mass, sodium intake, sleep apnoea, alcohol, family history and self-selection into shifts—could contribute. A single ABPM session may also capture an unusually demanding or quiet shift rather than a stable phenotype.

For practice, the evidence supports case-finding rather than automatic ABPM for every healthcare worker. Occupational health services should first use validated devices and standardised repeated office measurements. Out-of-office confirmation is reasonable when office pressure is high-normal, when sporadic readings are elevated, or when a worker has night-shift exposure or additional cardiovascular risk. ABPM is preferable when nocturnal pressure and dipping are important; well-taught HBPM is more scalable for repeated follow-up, but the two methods are not interchangeable.[4,17] A positive screen requires clinical assessment rather than an employment decision, and workplace responses should protect confidentiality while addressing sleep opportunity, roster design and modifiable risk.

Strengths include a reproducible search, transparent event counts, exact study confidence intervals, a random-effects model suited to sparse heterogeneous evidence, prediction intervals and sensitivity analyses. Important limitations remain. The protocol was not registered; Embase, Scopus and Web of Science were not directly searched; screening was performed in two passes rather than by two independent reviewers; one study was extracted from a public abstract; and the evidence came from only four countries. Five reports were single-centre or volunteer studies, all were cross-sectional, one measured only work-shift pressure, and one included undergraduate trainees. Thresholds and denominators varied, and the number of studies was too small for reliable publication-bias testing or meta-regression.

CONCLUSION

Masked hypertension is a credible hidden occupational-health problem, with a pooled prevalence of 17.1 percent in the available healthcare-worker samples. The certainty and geographical reach of this estimate are limited. Multicentre, prospectively registered studies using repeated standardized office measurement, validated 24-hour ABPM and clearly defined workforce denominators are needed before universal screening or region-specific prevalence claims are justified.

Declarations

- **Ethical approval:** This article is a systematic review and meta-analysis based exclusively on previously published data and does not contain any studies with human participants or animals performed by any of the authors. Therefore, institutional ethical approval was not required.
- **Informed consent:** Not applicable.
- **Funding: No external funding was received for this study.**
- **Conflict of interest:** The authors declare no conflicts of interest.
- **Data availability:** All data analysed in this study were obtained from published articles included in the systematic review and meta-analysis. Relevant extracted data are presented within the manuscript and supplementary material.
- **Authors' contributions:** BSB, FC, SA, HK, GRS and PK contributed to the conception, literature review, data interpretation, manuscript preparation and critical revision. All authors reviewed and approved the final manuscript.
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