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REVIEW OF THE LITERATURE

Predictors of Control Status of Hypertension in India: A Systematic Review and Meta-analysis

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Abstract

Predictors of hypertension (HTN) control status have not been well understood in India. This information is crucial for policymakers and program managers to devise newer HTN control strategies and implement relevant policies and programs. Therefore, we undertook this meta-analysis to estimate the effect of various factors on the control status of HTN in India. We systematically searched PubMed and Embase for observational studies and community-based trials published between April 2013 and March 2021 conducted among people (≥ 15 years) with hypertension in India. Quality of studies was assessed using Newcastle Ottawa (NO) scale. Meta-analysis was performed using random effects model. We reported the effect of various factors on the prevalence of controlled HTN using pooled odds ratio (OR) with 95% confidence interval (CI). Of the 842 studies screened, we analyzed nine studies that included 2,441 individuals. Based on the NO scale, majority (90%) of studies had a low risk of bias. The odds of having controlled HTN were significantly higher among women (OR 1.78, 95% CI 1.62–1.95), those aged > 45 years (OR 1.69, 95% CI 1.44–1.97), and those residing in urban parts of India (OR 1.74; 95% CI 1.48–2.03). These measures varied considerably across different regions of the country. Very few studies reported data on the relationship between behavioural risk factors of non-communicable diseases (NCDs) and HTN control status. We did not find any statistically significant differences between behavioural risk factors of NCDs and HTN control status. To improve HTN control in India, the ongoing/newer HTN control programs need to target men, those aged 15–45, and rural residents. Future studies on HTN control determinants should report disaggregated data and use standardized definitions for behavioral risk factors to enhance reliability and comprehensiveness of findings on the determinants of HTN control in future reviews.

Keywords Hypertension · Blood pressure · Control status · Risk factors · Noncommunicable diseases

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Extended author information available on the last page of the article

Introduction

Globally, hypertension (HTN) is the largest preventable cause of cardiovascular disease (CVD). It is the leading contributor to the global burden of diseases, with over 1.3 billion people living with the condition (World Health Organization n.d.). Globally, the prevalence of HTN has almost doubled over the past 25 years, with a rapid increase in the low- and middle-income countries (LMICs), accounting for two-thirds (66%) of the global hypertensive population ("More than 700 Million People with Untreated Hypertension" n.d.). In India, HTN is one of the top attributes of the country's total disease burden (Indian Council of Medical Research, Public Health Foundation of India, and Institute for Health Metrics And Evaluation, n.d.).

A systematic review conducted in 2013 revealed that about one in four (29.8%) adults in India have HTN, with striking disparities across geographic regions (Anchala et al., 2014). A few large-scale studies also provided national estimates of the HTN prevalence (Geldsetzer et al., 2018; Prenissl et al., 2019; Ramakrishnan et al., 2019). Among the hypertensive patients, uncontrolled blood pressure (BP) status is the crucial driver for HTN-associated cardiovascular events such as stroke and ischaemic heart disease. Therefore, lowering the BP levels is vital and could reduce the incidence of stroke, myocardial infarction, and heart failure by 40%, 25%, and 50%, respectively (Staessen et al., 2005).

Despite this evidence, globally, only about one-tenth (13%) of patients with HTN have their blood pressure under control, and it is abysmally low among the LMICs (7.7%) when compared to high-income countries (28.4%) (Sarki et al., 2015). In the review conducted in India in 2013, only about one-tenth (10.7%) and one-fifth (20.2%) of patients with HTN in rural and urban India, respectively, had their BP under control (Anchala et al., 2014).

In cognizance of the rising prevalence of HTN, and poor control status among the patients, India has committed to improving HTN control levels by 25% by 2025 ("India—National_Action_Plan_and_Monitoring_Framework_Prevention_NCD_2013.Pdf.). In line with this, India has launched several population-based HTN control initiatives during the last decade. This includes opportunistic screening for HTN among all adults (≥ 30 years) visiting public healthcare facilities; ("Training Manual for NCD Programme Managers at State and Disctrict Level_0.Pdf.) population-based screening for HTN followed by community-based follow-up of patients for treatment and adherence; (National Centre for Disease Control and Ministry of Health and Family Welfare, n.d.) successful implementation of the India Hypertension Control Initiative (IHCI) (Kaur et al., 2021), and Ayushman Bharat program to render preventive, promotive and accessible primary healthcare services for NCD care nationwide ("Ayushman Bharat –Pradhan Mantri Jan AarogyaYojana (AB-PMJAY) to Be Launched by Prime Minister Shri Narendra Modi in Ranchi, Jharkahnd on September 23, 2018" n.d.).

Despite these initiatives, a recent review on the control status of HTN conducted by the authors of this study in 2022 found only a marginal increase in the overall prevalence of HTN control (15%) compared with the previous national

estimates. Therefore, this calls for additional robust evidence from systematic reviews on factors influencing HTN control among the Indian population. But, such evidence is a longstanding lack in India to date. Therefore, realizing this evidence gap essential for planning and implementing HTN control programs, we undertook this study to assess the effect of various factors on the controlled status of HTN in India. The findings could offer crucial insights into the patient groups that need to be targeted for HTN control and guide reprioritizing implementation strategies of the ongoing HTN control interventions in the country.

Methodology

Design and Registration

This systematic review and meta-analysis is an extension of our previous work (Kumar et al., 2023), which was registered in PROSPERO (No.: CRD42021239800). The present review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement 2020.

Eligibility Criteria

Observational studies and community-based trials among participants aged ≥ 15 years, conducted in India, which reported the relevant exposure (age, gender, study setting, geographic region, current smoking, current alcohol use, overweight/obesity), and used JNC 7 criteria (Systolic Blood Pressure < 140 mmHg and < 90 mmHg Diastolic Blood Pressure) for assessing control status of HTN (outcome) were included in the review ("New Hypertension Guidelines: JNC 7 [Internet]. [Cited 2022 Mar 7]. Available from: https://Www.Jwatch.Org/Jw20030530 0000001/2003/05/30/New-Hypertension-Guidelines-Jnc-7," n.d.). Studies published in languages other than English or published as reviews, meta-analysis, letters, editorials, or comments were excluded.

Search Strategy

We systematically searched in electronic databases PubMed and Embase using appropriate Medical Subject Headings (MeSH), Emtree terms, and free text words. A list of key terms and their synonyms were used for searching, along with relevant truncations, wild search, and proximity searching. The final search was conducted by combining individual searches using boolean operators "AND" and "OR". We used filters to select studies published from April 2013 to March 2021 because a systematic review on the prevalence of controlled status of HTN has included studies published till April 2013 (Kumar et al., 2023). The detailed search strategy is reported in the supplementary file.

Study Selection Process

This involved two steps. Firstly, all the articles sourced were collated, and duplicates were removed using Zotero (version 5.0). Three reviewers (SMK, JA, and SE) independently screened the title and abstract of each study against the eligibility criteria using a web-based application, 'Rayyan' ("Rayyan, Intelligent Systematic Review [Internet]. [Cited 2021 Dec 9]. Available from: https://Rayyan.Ai/Cite," n.d.) and the full text of all eligible studies were retrieved. In the second step, full text articles were reviewed against the eligibility criteria (SMK, PS, JA, and SE) concerning study design, exposure, and outcome. Those articles that satisfied the criteria were selected for the study. In both steps, disagreements between the reviewers during the selection process were resolved through consensus or with the help of another reviewer. It is important to note that the total number of full text articles reviewed against the eligibility criteria of this review, were the ones included in the previous review conducted by the authors (ref). The study selection process is presented in Fig. 1.

Data Extraction

We extracted data from the selected full-text studies using a data extraction form developed in Microsoft Excel 2019 (Microsoft Corporation). The form included author information, year of conducting the study, year of publication, sample size, sampling strategy, study setting (rural or urban), geographical region of the study, quality-related information, exposure, and outcome assessment methods, number of participants in exposure and outcome groups, and number of exposed and non-exposed participants having the outcome. Data extraction was performed by SMK and was independently verified by JA and PS.

Risk of Bias Assessment

We assessed all studies included in the review for risk of bias using the Modified Newcastle–Ottawa (NO) scale. Two reviewers (JA and PS) performed this independently and arrived at the quality score. Disagreements between the two reviewers were resolved through consensus and/or consultation with the third reviewer (SMK). Studies with a score of ≥ 8 were considered high-quality (low risk of bias), score of 4–7, and score ≤ 3 were considered moderate and low-quality studies (high risk of bias), respectively ("Ottawa Hospital Research Institute [Internet]. [Cited 2022 Mar 7]. Available from: http://Www.Ohri.ca/Programs/Clinical_epidemiology/Oxford.Asp," n.d.).

Data Synthesis and Statistical Analysis

The outcome measures were factors associated with controlled HTN among the known hypertensive patients in India. We performed Meta-analysis in STATA

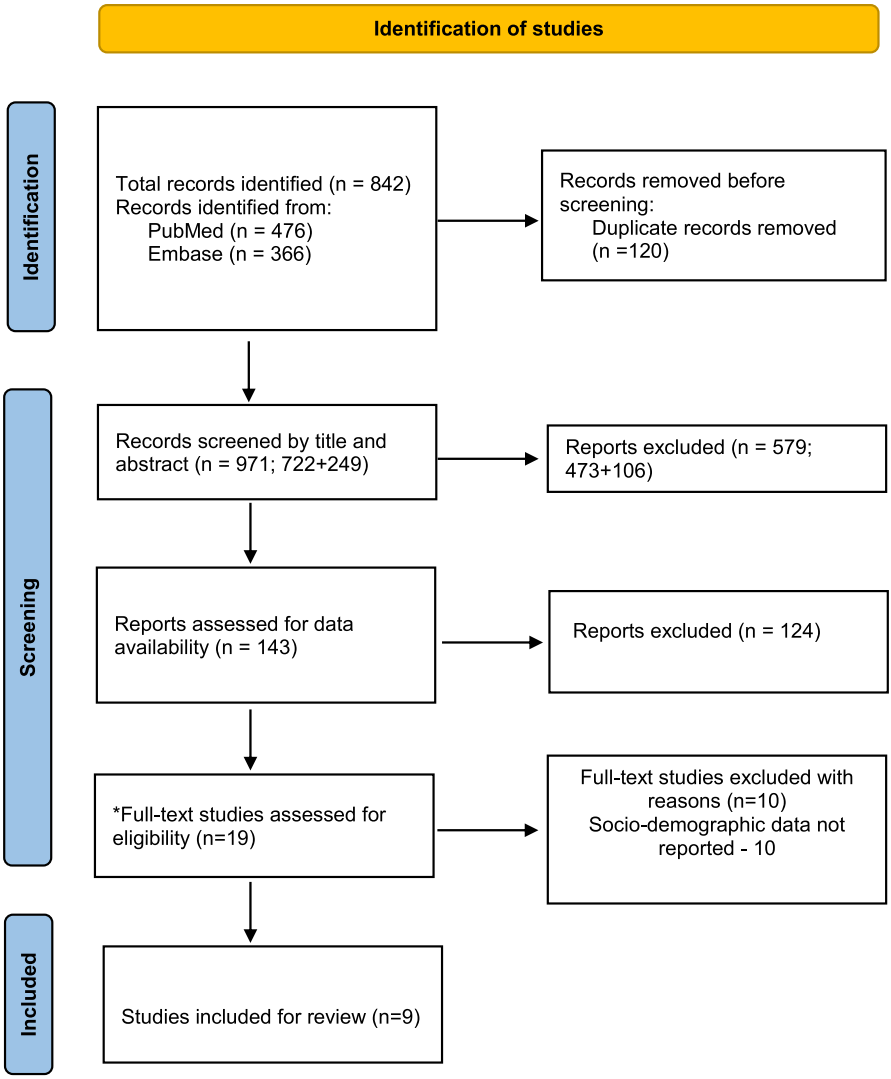

Fig. 1 PRISMA flowchart showing study selection process. *The full text studies assessed for the eligibility in this review were the ones included in the previous review conducted by the authors (Kumar et al., 2023)

14.0 (StataCorp, College Station, TX, USA), using the "metan" package. Random effects model was used to estimate the pooled estimates of outcome variables weighted by inverse of variance. The pooled estimate was reported as odds ratio with 95% Confidence Interval.

We performed Cochrane's Q statistic and I^2 statistic to assess heterogeneity between the included studies. I^2 statistics of $<25\%$, 25–75% and $>75\%$ were considered mild, moderate and high level of heterogeneity, respectively ("Higgins JPT,

Thompson SG, Deeks JJ, Altman DG. Measuring Inconsistency in Meta-Analyses. BMJ. 2003 Sep 6; 327(7414):557–60.," n.d.).

Results

Screening and Selection of Studies

We identified 842 studies, 476 and 366 from PubMed and Embase, respectively. After removing 120 duplicates, the title and abstracts of the remaining 722 studies were screened as per eligibility criteria, and 579 studies were excluded. The full text of the remaining 143 studies was reviewed in detail concerning the eligibility criteria, and nine studies were included in this review. This is presented using PRISMA 2020 flow diagram (Fig. 1).

Characteristics of Included Studies

Study Characteristics

Nine studies that reported various factors associated with the control status of hypertension were included. A summary of all studies included in this systematic review is given in Table 1. All studies were cross-sectional, and majority (67%) were conducted in both urban and rural areas. The total number of hypertensive populations included in the selected studies was 21,615. The factors associated with HTN control was assessed among 2,441 individuals. Among the included studies, 33% of them were from Northern India, followed by the west (22%), south (11%), and east (11%). About one-fifth (22%) were multicentric studies. The sample size included in the studies ranged from 277 to 18,028.

Methodological Aspects of the Included Studies

Around 56% of included studies employed multistage random sampling, and the rest used stratified and cluster random sampling. All the studies adhered to the JNC 7 guideline (ie. Systolic BP < 140 mmHg and Diastolic BP < 90 mmHg) for determining the HTN control status. All the studies used at least two readings for determining participants' blood pressure. Only three studies (33%) reported participants' mean or median age. The mean (*SD*) age of participants included in this review was 53.7 (6.6) years.

Risk of Bias Assessment

We performed risk of bias assessment for all the studies included in the review using the Modified Newcastle Ottawa scale (Table 2) (Luchini et al., 2017). Around 90% (8 out of 9 studies) of studies had a low risk of bias. One study by Busingye et al. had a high risk of bias in the selection and outcome bias domains.

Table 1 Summary characteristics of studies included in the systematic review (n = 9)

SN	First author and year of study	Sampling method	Age group (years)	Sample size	Place	State	Geographic region	Criteria for exposure (smoking/alcohol, overweight/obesity)
1	Tripathy et al. (2017)	Multistage stratified	18–69	5055	Punjab	Punjab	North	Smoking- smoked in past 30 days Alcohol- consumed alcohol in last one year Obesity- BMI ≥ 27.5 kg/m^2
2	Kanungo et al. (2017)	Multistage random	> 18	18,028	Malda	West Bengal	East	Not reported
3	Yip et al. (2013)	Stratified random	> 40	3591	Mumbai	Maharashtra	West	Smoking—current smoker Overweight—25 to 29.9 kg/m^2 Obesity—30 kg/m^2
4	Busingye et al. (2017)	Stratified simple random	> 18	277	Chitoor	Andhra Pradesh	South	Smoking- smoked any tobacco products daily during the current and in the past Alcohol- drinking at least once in past 12 months Overweight—23 to < 25 kg/m^2 Obese—25 kg/m^2
5	Roy et al. (2017)	Multistage cluster random	35–65	Survey 1- 5510 Survey 2- 3940	New Delhi	New Delhi	North	Smoking- NA Alcohol- any use in the last 12 months Overweight- BMI 25 to < 30 kg/m^2 Obese—BMI ≥ 30 kg/m^2

Table 1 (continued)

SN	First author and year of study	Sampling method	Age group (years)	Sample size	Place	State	Geographic region	Criteria for exposure (smoking/alcohol, overweight/obesity)
6	Irazola et al. (2016)	Multistage random	35–74	14,813	Multisite	Multisite[#]	Not Applicable	Not reported
7	Lloyd-Sherlock et al. (2014)	Multistage stratified random	≥50	6319	Multisite	Multisite[#]	Not Applicable	Not reported
8	Moser et al. (2014)	NA	>18	10,671	Mumbai	Maharashtra	West	Not reported
9	Goswami et al. (2016)	Cluster random	≥60	710	New Delhi	New Delhi	North	Not reported

Table 2 Quality assessment of the studies included in the systematic review (n = 9)

	Item	Author							
		Tripathy et al	Businge et al	Ambuj Roy et al	Irazola et al	Lloyd-Sherlock et al	Moser et al	Goswami et al	Yip et al
A	Selection	4	1	4	4	4	4	5	4
	Representativeness of the sample	✓	✗	✓	✓	✓	✓	✓	✓
	Sample size	✓	✓	✓	✓	✓	✗	✓	✓
	Non-respondents	✗	✗	✓	✓	✗	✗	✓	✗
	Ascertainment of the exposure (risk factor)	✓	✗	✗	✓	✓	✓	✓	✓
B	Comparability	2	1	2	2	2	2	2	2
C	Outcome	3	1	2	3	3	3	3	3
	Assessment of the outcome	✓	✓	✓	✓	✓	✓	✓	✓
	Statistical test	✓	✗	✓	✓	✓	✓	✓	✓
	Total	9	3	8	9	9	9	10	9

Factors Associated with the Controlled Status of HTN

Three out of nine studies reported the association between age group and HTN-controlled status. In India, the pooled odds of having controlled HTN among those aged > 45 (OR 1.69, 95% CI 1.44–1.97) was significantly higher by 1.69 times compared to those aged 18–45. This association was statistically significant and had substantial heterogeneity (I^2 of 81.2%, *p*-value = 0.005) between the studies that reported this association (Fig. 2). This association was also observed in the eastern (OR 2.6, 95% CI 1.9 to 3.5) and northern (OR 1.5, 95% CI 1.1 to 1.9) regions of the country. No study has reported this association in the southern and western parts of the country (Supplementary Fig. 1).

All studies included have reported the association between gender and HTN control status. The pooled OR for women having controlled HTN was 1.78 (95% CI 1.62 to 1.95), indicating that women have 1.78 times higher odds of having controlled HTN than men. This association was statistically significant, and the studies had substantial heterogeneity (I^2 of 90%, *p*-value = 0.001) (Fig. 3). The pooled OR for women having a comparatively higher level of controlled HTN was highest in North India (OR 2.89, 95% CI 2.43 to 3.43) followed by West (OR 1.42), South (OR 1.1), and Eastern (OR 1.1) India (Supplementary Fig. 2).

Two studies have reported the association of alcohol consumption, smoking status, and BMI with HTN control status. The pooled ORs for current smoking, current alcohol use, and Overweight/obesity with HTN controlled status were 1.04 (95% CI 0.56–1.94), 0.64 (95% CI 0.30–1.36), and 1.34 (95% CI 0.73–2.45) indicating that there was no statistically significant association (Supplementary Figs. 3, 4, 5). Although nine studies were included in this review, the absence of disaggregated data for these variables rendered only two studies for estimating the pooled ORs for these factors.

Three out of nine studies have reported the association between study setting and HTN controlled status. People residing in urban India have 1.74 (95% CI 1.48–2.03) times higher odds of having controlled HTN than those living in rural parts. This association was statistically significant with significantly higher heterogeneity (I^2 of 90%, *p*-value = 0.001) (Fig. 4). The pooled OR for

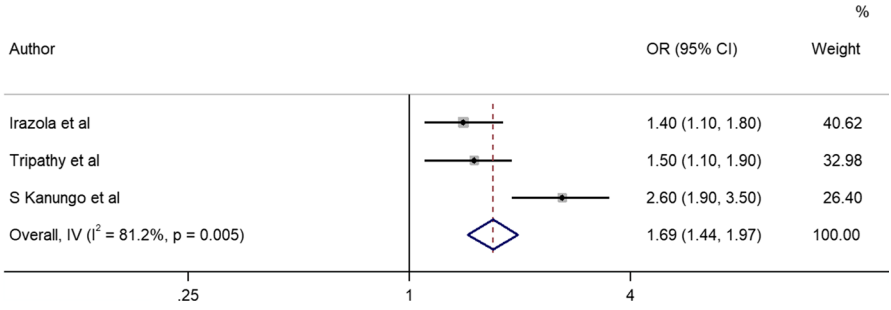

Fig. 2 Forest plot showing the association between age groups and controlled status of HTN in India (2013–2021) (n = 3)

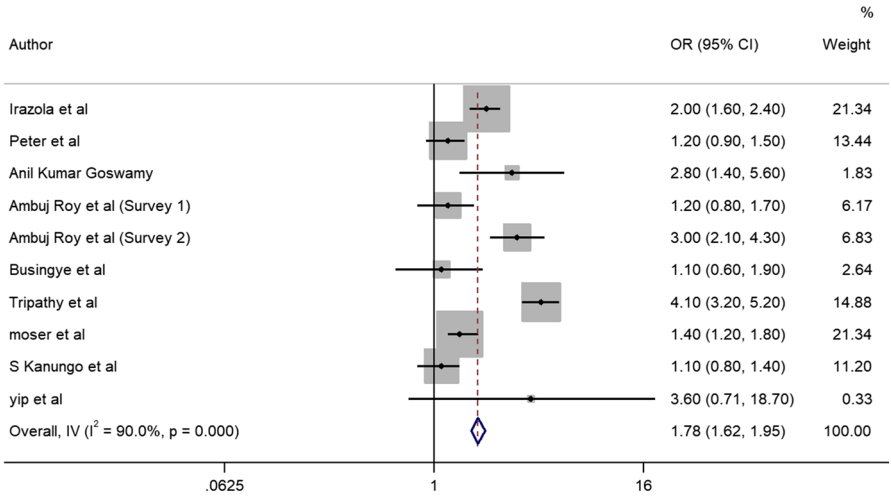

Fig. 3 Forest plot showing the association between gender and controlled status of HTN in India (2013–2021) (n = 9)

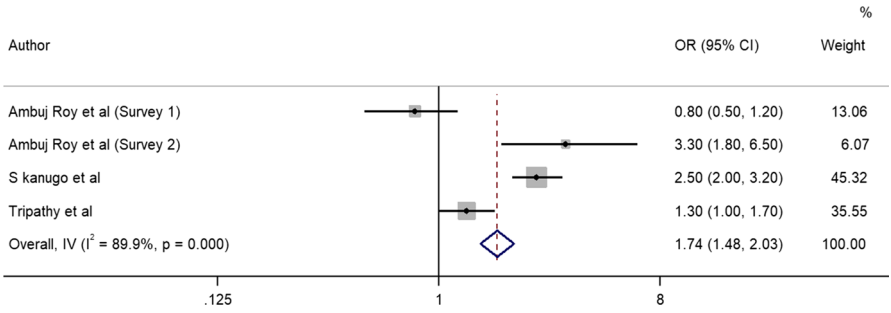

Fig. 4 Forest plot showing the association between study setting (Urban and Rural) and controlled status of HTN in India (n = 3)

controlled HTN in urban parts of Eastern India was comparatively higher (OR 2.50, 95% CI 1.98 to 3.16) when compared to urban parts of Northern India (OR 1.28, 95% CI 1.04 to 1.59) (Supplementary Fig. 6).

Publication Bias

The funnel plot demonstrated mild asymmetry. However, Egger's test performed for assessing publication bias showed an absence of publication bias (Co-efficient: 0.25, 95% CI − 5.6 to 6.1) with a *p*-value of 0.924 (Fig. 5).

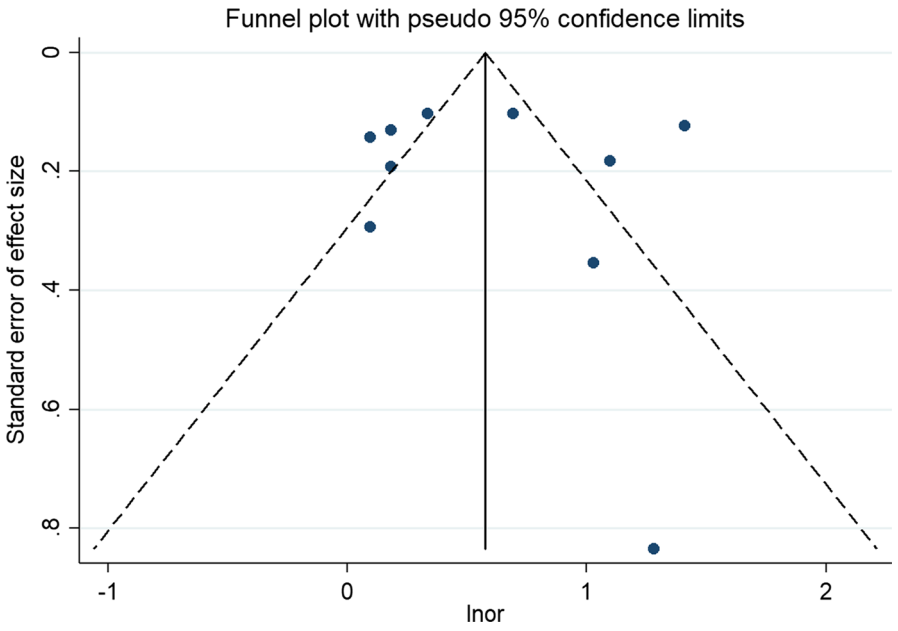

Fig. 5 Funnel Plot (n = 9)

Discussion

Key Findings of the Review

We found that the odds of having controlled HTN were significantly higher among women (OR 1.78), those aged > 45 years (OR 1.69), and those patients residing in urban parts of India (OR 1.74). These measures of associations varied considerably across different regions of the country.

Association Between Gender and HTN Control Status

Among hypertensive patients in India, the odds of having controlled HTN was significantly higher in women than men. This finding is consistent with several large-scale studies conducted within India and other LMICs (Chow et al., 2013; Moser et al. 2014; Irazola et al. 2016). This observation could be primarily attributed to the well-established evidence of better treatment-seeking behavior among women compared to men (Moser et al. 2014; Galdas et al., 2005). Evidence also suggests that individuals' health-seeking behavior is the crucial determinant for early diagnosis, management, and better health outcomes in any health condition. Further, studies from India have shown a high prevalence of undetected and untreated HTN among men (Amarchand et al., 2022), which could be the reflection of sub-optimal

health-seeking behavior for HTN care, leading to higher odds of uncontrolled HTN observed in the study. Despite such evidence, studies investigating various predictors of treatment-seeking behavior for HTN care, especially among men in India, are scarce. Therefore, the public health authorities of NCD control need to prioritize the research plan to investigate the barriers and facilitators of health-seeking behaviors for HTN care among men. The insights gained would guide realigning the implementation strategies of the country's various ongoing HTN control programs.

We also found that the odds of women having controlled HTN differed across geographic regions of the country, with the highest odds in the north (OR 2.89) followed by the West (1.42), South (OR 1.1) and East India (OR 1.1). This observation was not surprising, as in a country as diverse as India in terms of food habits, culture, beliefs, socio-economic status, attitude towards healthcare, healthcare access, and utilization, and variations in HTN awareness and treatment across its states, could exert considerable influence on the control status of HTN across geographic regions. A multinational study across nine LMICs, including India, showed varying HTN control levels across geographic regions (Irazola et al., 2016). These variations across regions also indicate the need to elicit region-specific determinants of uncontrolled HTN that are imperative for implementing region-specific workable public health measures in India.

Age Group and HTN Control Status

In the study, the HTN controlled status was significantly higher among those aged > 45 years compared to 15–45 years. This is consistent with other studies from the Indian context (Tripathy et al., 2017; Kanungo et al., 2017; Irazola et al., 2016). It is well documented that awareness of HTN status and healthcare utilization greatly influences the control status of HTN among patients (Lee et al., 2022). HTN being a silent killer, older people have a higher probability of becoming aware of their hypertensive condition due to signs and symptoms, which remain undiagnosed for long periods in the younger population. In addition, various national and subnational HTN control initiatives such as population-based screening for NCD risk factors including HTN, (National Centre for Disease Control and Ministry of Health and Family Welfare, n.d.) staged expansion of IHCI that currently covers over 2.5 million people, (Indian Council of Medical Research and World Health Organization 1 Jan 22) and opportunistic screening for HTN at healthcare facilities targets those aged ≥ 30 years ("Training Manual for NCD Programme Managers at State and Disctrict Level_0.Pdf [Internet]. [Cited 2022 Mar 7]. Available from: https://Main.Mohfw.Gov.in/Sites/Default/Files/Training%20Manual%20for%20NCD%20Programme%20Managers%20at%20State%20and%20Disctrict%20Level_0.Pdf," n.d.) leading to higher probability of early diagnosis, treatment initiation and therefore better HTN control among the older population.

This finding signifies that the ongoing HTN control initiatives shall finetune its implementation strategies towards the young age group to improve their control status in this age group. Vast evidence also shows that the prevalence of undiagnosed and untreated HTN is comparatively higher among the younger population

necessitating special attention for remedial interventions. Further, it is well established that people's health beliefs on HTN shape their health-seeking behaviour for HTN prevention and control (Hayden, n.d.). Therefore, quantifying HTN related health beliefs of patients in terms of perceived susceptibility, severity, benefits, barriers and cues to action especially among younger patients would offer critical insights to devise strategies for improving awareness of HTN condition, and regular follow-up, which are also the major barriers in the ongoing HTN control programs in the country.

Behavioral Risk Factors and HTN Control Status

We found that current smoking, alcohol use, and obesity were not associated with HTN control status. This finding should be cautiously interpreted as only two studies had disaggregated frequency level data required for determining these associations. A few large-scale studies conducted in India during the last decade have also painted an unclear picture with mixed results (Businge et al., 2017; Kapoor et al., 2021; Kothavale et al., 2022; Yip et al., 2013). Therefore, future studies conducted on HTN control in India should provide necessary frequency level data to facilitate future evidence synthesis efforts. It is also important that when the number of studies published since 2013 was insufficient to provide clear evidence in this review, studies estimating the predictors of controlled HTN needs to be encouraged across geographic regions over the next years to address this gap through future systematic reviews to provide crucial insights for the ongoing HTN control interventions.

Study Setting and HTN Control Status

Consistent with previous literature, the odds of controlled HTN were significantly higher among urban residents compared to rural residents. Various established reasons could be comparatively low levels of awareness of HTN, socio-economic status, accessibility, and availability of healthcare facilities in rural areas. Corroborating with this finding, a previous systematic review conducted in 2013 also documented comparatively higher levels of controlled HTN among urban patients than rural patients (Anchala et al., 2014). It concerns that the urban–rural differences in HTN control continue to exist in the country. This necessitates improving accessibility and availability of HTN care through strategies like periodic outreach programs by frontline workers for HTN screening and follow-up visits, and evaluating emerging strategies such as telemedicine for HTN care.

Taking HTN care close to patient's residents is proven to improve early diagnosis and retention to care (Kaur et al., 2021). For instance, awareness of HTN among people who lived within five Km of healthcare facilities was considerably higher (Buor, 2003; Businge et al., 2017). This is likely to hold in other LMICs as in Nigeria; people do not travel beyond five km for preventive and curative services (Stock, 1983). Therefore, implementing successful strategies found elsewhere in other LMICs could improve the population control status of HTN in Indian settings with appropriate adaptations. Population-based HTN control program implemented

in Thailand has led to substantial improvement in HTN control status from 8.6% in 2004 to 30% in 2014 (World Health Organization. Country Office for Thailand, 2019). Among high-income countries, Canada has also improved its population-level HTN control level from 13.2% in 1992 to 64.6% in 2014 through community and clinic-based HTN control programs (McAlister et al., 2011).

In line with such successful initiatives elsewhere globally, and with such emerging evidence, several key initiatives launched during the last decade have been promising in India's strides towards improving HTN control. In particular, the IHCI launched in 2017 with established strategies of protocol-based treatment, patient-centered care, team-based care, reliable supply of anti-hypertensive drugs, and strong information systems have proven to improve the control status of patients by threefold when compared to baseline estimates in the implementation districts (Kaur et al., 2021). Currently, IHCI is being implemented in hundred districts covering over 2.5 million hypertensive patients (Indian Council of Medical Research and World Health Organization 1 Jan 22).

The Government of India also launched Ayushman Bharat Health and Wellness Centre initiative in 2018 to establish 1,50,000 HWCs across the country. This expansion of primary healthcare facilities would take primary healthcare for HTN closer to the community leading to increased awareness on HTN, early diagnosis and treatment initiation, and regular follow-up consultations that are likely to improve HTN control status among the rural populations ("Ayushman Bharat –Pradhan Mantri Jan AarogyaYojana (AB-PMJAY) to Be Launched by Prime Minister Shri Narendra Modi in Ranchi, Jharkahnd on September 23, 2018" n.d.).

Strengths and Limitations

To the best of our knowledge, this is the first review of the determinants of the controlled status of HTN in India. The major strength of this review is the rigorous methodology followed in the literature search and analysis. The majority of studies included for review had a low risk of bias which could enhance the generalizability of study findings.

This study also carries certain limitations. In all the tests of associations between individual exposures and HTN controlled status, we found significantly higher levels of between-study variations. This could be mainly attributed to methodological differences among studies such as sample size, sampling, study setting, the definition of exposures, etc. Therefore, results need to be interpreted in cognizance of the between-study heterogeneity observed in the meta-analyses. In this review, although we included nine studies, only three were included for deriving pooled effect sizes for age groups, and study setting due to lack of disaggregated data. Although three studies included satisfy the statistical requirement for meta-analysis, the striking difference in the effect estimates of various factors across geographic regions raises concerns about their representativeness. Future reviews conducted with adequate studies across Indian regions could increase the representativeness of regional-level estimates.

This review found no significant association between behavioral risk factors and HTN control status. Although previous individual large-scale studies have reported mixed results, between study variations in the definition of exposures (current smoking and alcohol use, overweight/obesity) could have considerable influence on the effect sizes of individual studies and thereby on the pooled estimate of this review. To address this lacuna, future studies carried out in the country should utilize standard definitions of these risk factors.

Conclusion

We found that the odds of having controlled HTN was significantly higher among women (OR 1.7), those aged > 45 years (OR 1.69), and those patients residing in urban parts of India (OR 1.69). These measures of associations varied considerably across geographic regions of the country signifying the need for determining region-specific predictors of controlled HTN. Based on the findings, we emphasize that newer/ongoing HTN control programs in the country need to target men, patients in 15–45 years, and those residing in rural parts of India to improve the control status of HTN in the country.

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Authors Contribution PS—Conceptualization, Methodology, Screening, Data Extraction, Investigation, Writing—original draft, Writing—review and editing. JA—Methodology, Screening, Data Extraction, Formal analysis, Software, Investigation, Writing—Original draft, Writing—review and editing. SMK—Methodology, screening, Data Extraction, Investigation, Validation, Writing- review and editing. SE—Methodology, Screening, Data Extraction, Investigation. AG—Validation, Writing- review and editing. SSK—Conceptualization, Methodology, Validation, Writing- review &editing, Supervision.

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Declarations

Conflict of Interest The authors declared that they have no conflict of interest.

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