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Systematic Review

Hypertension burden in Northwest India: a systematic review of prevalence, risk factors and care cascade in Punjab and Haryana (2021-2026)

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ABSTRACT

Hypertension is the leading modifiable risk factor for cardiovascular disease, stroke, and premature mortality globally. Punjab and Haryana, two high-income agricultural states of northwestern India, have consistently reported hypertension prevalence rates substantially exceeding the national average, driven by distinctive socio-cultural, dietary, and occupational risk profiles. A systematic review was conducted using PubMed/Medline, Google Scholar, and Web of Science for peer-reviewed studies published from January 2021 to May 2026 reporting hypertension prevalence and/or risk factors among adults (age ≥18 years) in Punjab or Haryana. PRISMA guidelines were followed. Of 400 records identified, 46 studies were included after rigorous screening. In Punjab, hypertension prevalence ranged from 24.3% to 40.1% in state-wide surveys, and reached 62% in Ludhiana. In Haryana, prevalence ranged from 17.26% to 59% across community and facility-based studies. A prospective cohort study documented a significant rise from 34.4% to 40.4% over eight years in rural Haryana. Hypertension awareness was 48.3%, treatment 30.9%, and control 18.3% in Punjab; in Haryana, awareness was 33.4%, treatment 26.3%, and control was only 12%. Major risk factors included increasing age, male sex, obesity, high dietary salt intake, physical inactivity, tobacco and alcohol use, diabetes mellitus, dyslipidaemia, and psychological stress. A novel finding was global DNA hypomethylation as an epigenetic correlate of hypertension in rural Punjab. The hypertension burden in Punjab and Haryana continues to rise with suboptimal awareness, treatment, and control (ATC) rates. Expansion of the India Hypertension Control Initiative, targeted dietary and occupational health programmes, and district-representative longitudinal studies are urgently required.

Keywords: Hypertension, Prevalence, Risk Factors, Punjab, Haryana, Blood Pressure

INTRODUCTION

Hypertension, commonly termed the "silent killer", is defined as a persistent elevation of systolic blood pressure (SBP) >140 mmHg and/or diastolic blood pressure (DBP) >90 mmHg, or the current use of antihypertensive medication.[1] It constitutes the single largest modifiable risk factor for cardiovascular disease, stroke, and chronic kidney disease worldwide.[2] The World Health Organization (WHO) estimated in its 2023 Global Report on Hypertension that over 1.3 billion adults globally suffer from raised blood pressure, yet only one in five have it adequately controlled.[3]

India bears a disproportionately high and growing burden of hypertension. The National Family Health Survey-5 (NFHS-5, 2019-21) reported hypertension prevalence of 34.2% in Punjab and 22.1% in Haryana.[4] Global analysis by the NCD risk factor collaboration documented a rising trend in blood pressure burden from 1975 to 2015, with

India contributing substantially to the increasing global prevalence.[5] Despite national programmes including the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) and the India Hypertension Control Initiative (IHCI), rates of ATC remain critically low across India.[6]

Punjab and Haryana, located in northwestern India, are characterised by high per-capita caloric intake, elevated alcohol and tobacco consumption among males, rapidly declining physical activity levels, and a high burden of obesity and metabolic syndrome.[7] State-wide STEPS survey data placed Punjab's adult hypertension prevalence at 40.1%, far above the national average of 25.3%.[8] Haryana, while historically recording lower prevalence than Punjab, has shown significant upward trends, particularly in occupational and elderly populations.[9]

Cardiovascular disease risk attributable to hypertension is particularly pronounced in the Indian subcontinent due to an earlier age of onset, greater propensity to target organ damage, and the co-existence of diabetes mellitus and dyslipidaemia as clustering risk factors.[2,10] The Green Revolution legacy of Punjab and Haryana, characterised by agricultural mechanisation, dietary energy surplus, and occupational sedentariness, has accelerated metabolic risk transitions that are now manifesting as an epidemic of non-communicable diseases, with hypertension at the forefront.[7] Understanding the contemporary epidemiology of hypertension in these two demographically distinct yet geographically contiguous states is therefore of high public health priority for northwestern India and for national cardiovascular disease prevention planning.

First comprehensive systematic review on hypertension in Punjab and Haryana (2009-2023) was published by Sekhon et al synthesising 34 primary studies.[11] Since that review, several important developments have occurred: publication of NFHS-5 data with district-level disaggregation; the first prospective cohort evidence of temporal change in Haryana; a novel epigenetic study from rural Punjab; and multiple new community-based studies from previously unrepresented districts. These developments necessitate an updated review.

The present systematic review aims to: (i) identify and synthesise all peer-reviewed evidence on hypertension prevalence in Punjab and Haryana published from January 2021 to May 2026; (ii) document modifiable and non-modifiable risk factors; (iii) assess trends in ATC; and (iv) evaluate district-level heterogeneity in hypertension burden within Punjab and Haryana; (V) identify research gaps and policy-relevant directions.

METHODS

Search strategy

A systematic literature search was conducted in three electronic databases: PubMed/MEDLINE, Google Scholar, and Web of Science, for articles published from January 2021 to May 2026. The following MeSH and free-text search terms were combined using Boolean operators: "hypertension" or "high blood pressure" or "elevated blood pressure" and "Punjab" or "Haryana" and "prevalence" or "incidence" or "risk factors" or "determinants." Additional searches were conducted using district names within both states. Reference lists of eligible articles were hand-searched. Only English-language full-text articles were included.

Inclusion criteria

Cross-sectional, cohort, ecological, or population-based surveillance study design. Published between January 2021 and May 2026. Conducted in Punjab or Haryana, or reporting data disaggregated for these states. Adult study population (age ≥18 years). Sample size ≥100 participants for primary studies. Full-text article available in English. Reporting at least one quantitative estimate of hypertension prevalence and/or associated risk factors.

Exclusion criteria

Case reports, conference abstracts, animal studies, editorial letters, or non-peer-reviewed publications. Studies exclusively covering adolescents or children (age <18 years). Studies reporting only national-level data without disaggregation for Punjab or Haryana. Duplicate publications of the same dataset.

Study selection and data extraction

Titles and abstracts of all retrieved records were screened by the primary author against inclusion/exclusion criteria. Potentially eligible articles were retrieved in full text for detailed evaluation. Data extracted from each eligible study included: first author, year, study design, geographic location (state, district, urban/rural), study population and age group, total sample size, male and female sample sizes (where reported), diagnostic criteria for hypertension, overall prevalence, sex-specific prevalence, awareness/treatment/control rates, and risk factors identified through multivariable analysis or significant associations.

PRISMA flow diagram

An initial search across all three databases yielded 400 records. After removal of duplicates (n=70), titles and abstracts of 330 records were screened, with 215 excluded (unrelated topic, other states, non-peer-reviewed). Of 115 full-text articles assessed for eligibility, 69 were excluded (pre-2021, duplicate datasets, sample size <100, no Punjab/Haryana-specific data, conference proceedings). A total of 46 studies were included: 20 Punjab-specific, 22 Haryana-specific, and 4 reporting both states and state-disaggregated national data (Figure 1).

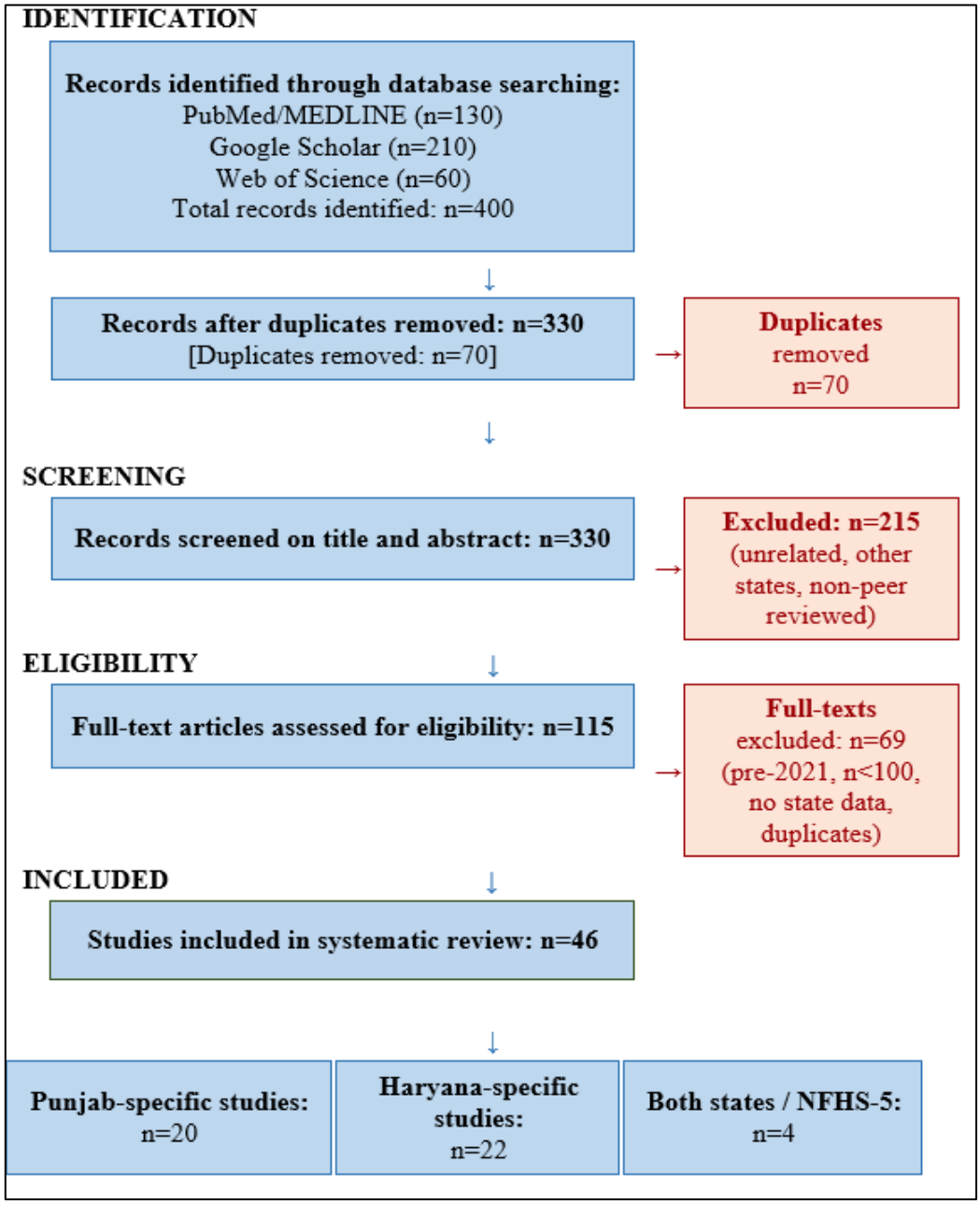

Figure 1: PRISMA flow diagram of study selection review period: January 2021 to May 2026, Punjab and Haryana, India.

RESULTS

Characteristics of included studies

The 46 included studies comprised 37 primary cross-sectional studies, 1 prospective cohort study (Longkumer et al. 2023), 4 NFHS-5, 1 case-control epigenetic study (Kaushik et al. 2024), 2 IHCI surveillance reports, and 1 systematic review (Sekhon et al).[11] Study populations included general community samples, occupational cohorts (industrial workers, police personnel), elderly populations, and OPD attendees. Hypertension was defined as SBP ≥140 mmHg and/or DBP ≥90 mmHg in most studies, consistent with JNC-7 criteria.

Prevalence of hypertension in Punjab (2021-2026)

Table 1 presents the verified prevalence data from studies conducted in or pertaining to Punjab between 2021 and 2026. The most representative state-wide estimate for Punjab comes from Thakur and Nangia, who applied the WHO STEPS methodology to a stratified sample of 5,127 adults aged 18-69 years across Punjab. The overall prevalence was 40.1%, with males significantly more affected at 47.4%. Awareness was 48.3%, treatment 30.9%, and control only 18.3%.[8]

Jaacks et al in the largest community-based study from Punjab, recruited 11,322 adults aged 30-60 years across

multiple districts and documented a hypertension prevalence of 24.3%. This lower estimate reflects the younger age range and community-intervention context of the cohort.[12]

Mitra et al reported an overall prevalence of 33.6% among 500 adults aged 18-69 years in district Amritsar, with males at 34.4% and females at 32.8%, demonstrating near-equal sex distribution in contrast to the male predominance in state-wide surveys.[13]

Singh et al studying adults aged ≥20 years in Ludhiana, documented an overall hypertension prevalence of 62% using the 2017 AHA/ACC guidelines. Rural populations were more likely to be unaware of their hypertensive status. Major risk factors included obesity, sedentary lifestyle, high salt intake, stress, alcohol, and hypercholesterolaemia.[14]

Kaushik et al conducted a population-based epigenetic study in Mansa district, screening 2,300 individuals and selecting 900 (450 hypertensive cases, 450 normotensive controls) for detailed analysis. Global DNA hypomethylation was a significant biological correlate of hypertension: hypertensives had significantly lower 5-methylcytosine (5mC) levels than normotensives (0.65 vs. 0.72; p=0.01). Individuals in the lowest quartile of 5mC were at 1.67 times higher odds of hypertension (95% CI: 1.206-2.315; p=0.01). This is the first epigenetic evidence on hypertension from Punjab.[15]

Table 1: Prevalence of hypertension in Punjab (2021-2026).

Authors and year	Age group (in years)	Sample size	Area	Study design	Overall	Male	Female
Mitra et al, 2021[13]	18-69	500	Amritsar, Punjab	Cross-sectional	33.6%	34.4%	32.8%
Jaacks et al, 2022[12]	30-60	11,322	Punjab (multiple districts)	Community-based cross-sectional	24.3%	NR	NR
Thakur et al 2022[8]	18-69	5,127	Punjab (state-wide STEPS)	Cross-sectional (STEPS)	40.1%	47.4%	NR
Mohammad et al 2024[29]	≥15	NFHS-5 data	Punjab (NFHS-5)	Cross-sectional (secondary analysis)	34.2%	NR	NR
Kaushik et al, 2024[15]	30-75	2,300 screened; 900 in case-control	Mansa, rural Punjab	Population-based case-control (epigenetic study)	Not a prevalence study	NR	NR
Sekhon et al 2024[11]	≥18	34 studies reviewed	Punjab (multiple districts)	Systematic review	24.3-40.1%	32.4-88.2%	30-84.7%
Pedgaonkar et al 2025[25]	≥15	NFHS-5 data	Amritsar, Bathinda, Hoshiarpur, SBS Nagar	Ecological (NFHS-5)	Household clustering >20% (Amritsar: 37.3%)	NR	NR
Singh et al, 2025[14]	≥20	Not stated	Ludhiana, Punjab	Cross-sectional	62%	NR	NR
Kaur et al, 2025 (IHCI)[22]	18-69	~624 per district	Bathinda and Hoshiarpur, Punjab	Population-based surveillance	Reports ATC rates (Table 5)	NR	NR

*NR: Not reported; ATC: Awareness, treatment, Control; STEPS: STEPwise approach to surveillance; NFHS-5: National family health survey 5; SBS Nagar: Shahid Bhagat Singh Nagar; IHCI: India hypertension control initiative. †Gupta et al 2020 and Narang et al. 2020 included in Haryana table as comparators (published just before review period).

Prevalence of hypertension in Haryana (2021-2026)

Table 2 summarises verified prevalence data from studies conducted in or pertaining to Haryana between 2021 and 2026. The state-wide STEPS survey by Thakur and Nangia documented a hypertension prevalence of 26.2% in Haryana among 5,078 adults aged 18-69 years, with males more affected at 29.5%. Awareness in Haryana was only 33.4%, treatment 26.3%, and control 12%.[8]

The most critical new evidence from Haryana is the 8-year prospective cohort study by Longkumer et al which followed 1,542 adults (age ≥30 years) from Palwal district. Hypertension prevalence increased significantly from 34.4% (95% CI: 32.0-36.9%) to 40.4% (95% CI: 37.5-43.4%) (p=0.002). Median SBP rose from 120 mmHg to 125.5 mmHg (p<0.001).

Among hypertensives, awareness improved from 9.6% to 31.8%, treatment from 8.8% to 27.3%, and control from 5.0% to 9.6%, yet all remained critically inadequate.[9]

Yadav et al documented an alarmingly high prevalence of 48.6% among 323 industrial workers in Faridabad. Age, smoking, alcohol, longer employment duration, and deranged lipid profiles were independently significant risk factors.[16]

Vashist et al in a door-to-door survey of 300 adults aged 30-70 years in Mankrola village, Gurugram, reported an overall prevalence of 21.7% (males: 22%, females: 21%). Salt intake exceeding 20 g/day was associated with a hypertension prevalence of 38%, and BMI ≥30 kg/m² with 44%.[17]

Narang et al studying Employee's State Insurance (ESI) beneficiaries across four districts of Haryana (Faridabad, Palwal, Gurgaon, and Kurukshetra), documented the lowest regional prevalence of 17.26% among 365 adults aged 19-60 years, reflecting the younger working-age study population.[18] Silan et al reported the highest facility-based prevalence of 59% among 100 adults aged 30-60 years attending a facility in Sonipat, with males accounting for 39% and females for 20 percent of the sample.[19]

Risk factors of hypertension in Punjab (2021-2026)

Table 3 summarises risk factors for hypertension identified in Punjab studies during the review period. Risk factors are categorised into modifiable (obesity, physical inactivity, tobacco/alcohol use, high salt intake, psychosocial stress, dyslipidaemia, and epigenetic factors) and non-modifiable (age, sex, family history).

Among the non-modifiable determinants, advancing age and male sex consistently emerged as the strongest predictors of hypertension across Punjab studies.[8,13,14] Among modifiable risk factors, obesity was the most ubiquitously documented, followed by high dietary salt intake, physical inactivity, and tobacco and alcohol use. Psychosocial stress, particularly anxiety and depression emerged as a significant and previously underappreciated risk factor in Fatehgarh Sahib, disproportionately affecting women.[20] The scientifically novel finding from the review period is the demonstration of global DNA hypomethylation as an epigenetic correlate of hypertension in rural Mansa, Punjab, pointing to a role for nutritional epigenetics, specifically folate-mediated one-carbon metabolism, in the pathogenesis of hypertension in this region.[15] Collectively, the Punjab risk factor data underscore the need for integrated, multi-domain lifestyle interventions alongside novel biological screening strategies in high-risk communities.

Risk factors of hypertension in Haryana (2021-2026)

Table 4 summarises risk factors for hypertension identified in Haryana studies during the review period. The risk factor profile documented in Haryana largely parallels that of Punjab, though with important contextual differences. Increasing age and male sex were the most consistently reported non-modifiable risk factors across community-based and facility-based studies.[8,21] Notably, in the Palwal cohort, rising body mass index over the 8-year follow-up period was independently associated with the progression to hypertension, providing prospective evidence for the causal role of obesity.[9] Among industrial workers in Faridabad, occupational-specific determinants including prolonged employment duration and dyslipidaemia were independently significant, highlighting the need for targeted occupational health surveillance in Haryana's rapidly expanding industrial belt.[16] High dietary salt intake and excess body weight also remained consistently reported modifiable risk factors in rural Haryana, consistent with state-wide STEPS survey findings.[8,17]

Awareness, treatment and control

Table 5 summarises documented rates of hypertension awareness, treatment, and blood pressure control in Punjab and Haryana. Across both Punjab and Haryana, a persistent and wide care cascade gap is evident. In Punjab, the STEPS survey documented awareness at 48.3%, treatment at 30.9%, and control at only 18.3%, while Haryana recorded lower rates at 33.4%, 26.3%, and 12.0%, respectively.[8] The 8-year prospective data from Palwal, Haryana, confirm that even with improvement in awareness (9.6% to 31.8%) and treatment (8.8% to 27.3%) over time, blood pressure control advanced only marginally from 5.0% to 9.6%, highlighting a fundamental treatment effectiveness gap.[9] The IHCI, through decentralisation of care to Health and Wellness Centres in Bathinda and Hoshiarpur and the implementation of standardised drug and dose protocols, represents the most structured programmatic response to this gap in Punjab.[22-24] Both states remain far from achieving the WHO 80-80-80 target, underscoring the urgency of scaling up evidence-based hypertension management programmes across all districts (Figure 2).

Table 2: Prevalence of hypertension in Haryana (2021-2026).

Authors and year	Age group (in years)	Sample size	Area	Study design	Overall	Male	Female
Thakur et al 2022[8]	18-69	5,078	Haryana (state-wide STEPS)	Cross-sectional (STEPS)	26.2%	29.5%	NR
Silan et al, 2022[19]	30-60	100	Sonipat, Haryana	Facility-based cross-sectional	59%	39%*	20%*
Sindwani et al, 2023[21]	≥20	713	Hissar (CHC Barwala), Haryana	OPD-based cross-sectional	28.1%	NR	56% of HTN pts-female
Longkumer et al, 2023[9]	≥30	1,542	Palwal, rural Haryana	8-year prospective cohort	34.4% (baseline); 40.4% (endline) p=0.002	NR	NR

Continued.

Authors and year	Age group (in years)	Sample size	Area	Study design	Overall	Male	Female
Yadav et al, 2024[16]	Working adults	323	Faridabad (industrial workers), Haryana	Cross-sectional	48.6%	NR	NR
Pedgaonkar et al 2025[25]	≥15	NFHS-5 data	Kurukshetra, Haryana	Ecological (NFHS-5)	Household clustering >20%	NR	NR
Vashist et al, 2026[17]	30-70	300	Gurugram (Mankrola village), Haryana	Cross-sectional, door-to-door	21.7%	22%	21%
Gupta et al, 2020†[26]	60-75	386	Ballabgarh, Haryana	Cross-sectional	50.3%	46%	53.3%
Narang et al, 2020†[18]	19-60	365	Faridabad, Palwal, Gurgaon, Kurukshetra	Cross-sectional	17.26%	13.15%	4.10%

*NR: Not Reported; STEPS: STEPwise approach to Surveillance; CHC: Community health centre; OPD: Outpatient Department. *Silan et al, male % and female % represent proportion of total sample, not sex-specific prevalence rates. †Studies published in 2020 included as comparators.

Table 3: Risk factors of hypertension in Punjab (2021-2026).

Authors and years	Age group (in years)	Area	Study design	Risk factors identified
Mitra et al, 2021[13]	18-69	Amritsar	Cross-sectional	Age; high BMI; tobacco and alcohol use; physical inactivity; high salt intake; family history of hypertension
Jaacks et al, 2022[12]	30-60	Punjab (multiple districts)	Community-based	Obesity; physical inactivity; tobacco use; high caloric intake; sedentary behaviour
Thakur et al 2022[8]	18-69	Punjab (state-wide)	STEPS cross-sectional	Male sex; age (45-69 yr); marital status; alcohol use; obesity; salt intake (≥5 g/day)
Shergill et al, 2022[20]	18-69	Fatehgarh Sahib	Cross-sectional	Anxiety and depression (significantly associated with hypertension, especially among women)
Kaushik et al, 2024[15]	30-75	Mansa, rural Punjab	Population-based (epigenetic)	Global DNA hypomethylation (lower 5mC levels in hypertensives vs normotensives, p=0.01); folate deficiency; increasing age
Sekhon et al, 2024[11]	≥18	Punjab (multiple districts)	Systematic review	Increasing age; male sex; high BMI/obesity; family history; anxiety and depression; sedentary lifestyle; tobacco and alcohol; high salt intake; diabetes mellitus; dyslipidaemia
Singh et al, 2025[14]	≥20	Ludhiana	Cross-sectional	Obesity; sedentary lifestyle; high socioeconomic status; salt intake; stress; alcohol; hypercholesterolaemia; low literacy (rural areas)

*BMI: Body mass index; 5mC: 5-methylcytosine (global DNA methylation marker); STEPS: STEP wise approach to Surveillance.

Table 4: Risk factors of hypertension in Haryana (2021–2026).

Authors and years	Age group (in years)	Area	Study design	Risk factors identified
Thakur et al 2022[8]	18-69	Haryana (state-wide)	STEPS cross-sectional	Male sex; age; tobacco use; alcohol; physical inactivity; overweight/obesity; high salt intake; low fruit intake; DM
Silan et al, 2022[19]	30-60	Sonipat	Facility-based cross-sectional	Family history, BMI, physical inactivity, DM, smoking, alcohol
Sindwani et al, 2023[21]	≥20	Hissar (CHC Barwala)	OPD-based cross-sectional	Increasing age (p<0.001); higher proportion of hypertensives were female (56%); unhealthy diet; sedentary lifestyle
Longkumer et al, 2023[9]	≥30	Palwal, rural Haryana	8-year prospective cohort	Increasing age; rising BMI over 8-year follow-up; low awareness; poor treatment adherence; inadequate BP control
Yadav et al, 2024[16]	Working adults	Faridabad (industrial)	Cross-sectional	Age, smoking, alcohol, longer duration of employment, deranged total cholesterol, triglycerides and LDL-C, DM, obesity
Vashist et al, 2026[17]	30-70	Gurugram (Mankrola)	Door-to-door cross-sectional	High salt intake >20 g/day; BMI ≥30 kg/m²; current smoking; smokeless tobacco; alcohol; perceived psychological stress; low education; semi-professional occupation

*BMI: Body mass index; LDL-C: Low-density lipoprotein cholesterol; CHC: Community health centre; OPD: Outpatient department.

Table 5: Hypertension ATC rates in Punjab and Haryana, (2021-2026).

Studies	State	Survey year	Awareness (%)	On treatment (%)	Controlled (%)
Thakur et al 2022[8]	Punjab	2014-15	48.3	30.9	18.3
Thakur et al 2022[8]	Haryana	2016-18	33.4	26.3	12.0
Longkumer et al, 2023 (baseline)[9]	Haryana (Palwal)	2011-14	9.6	8.8	5.0
Longkumer et al, 2023 (endline)[9]	Haryana (Palwal)	2019-22	31.8	27.3	9.6
Kaur et al, 2025 (IHCI)[22]	Punjab (Bathinda, Hoshiarpur)	2018-19	Improved via IHCI	Improved via HWC decentralisation	<50% target

*IHCI: India Hypertension Control Initiative; HWC: Health and Wellness Centre.

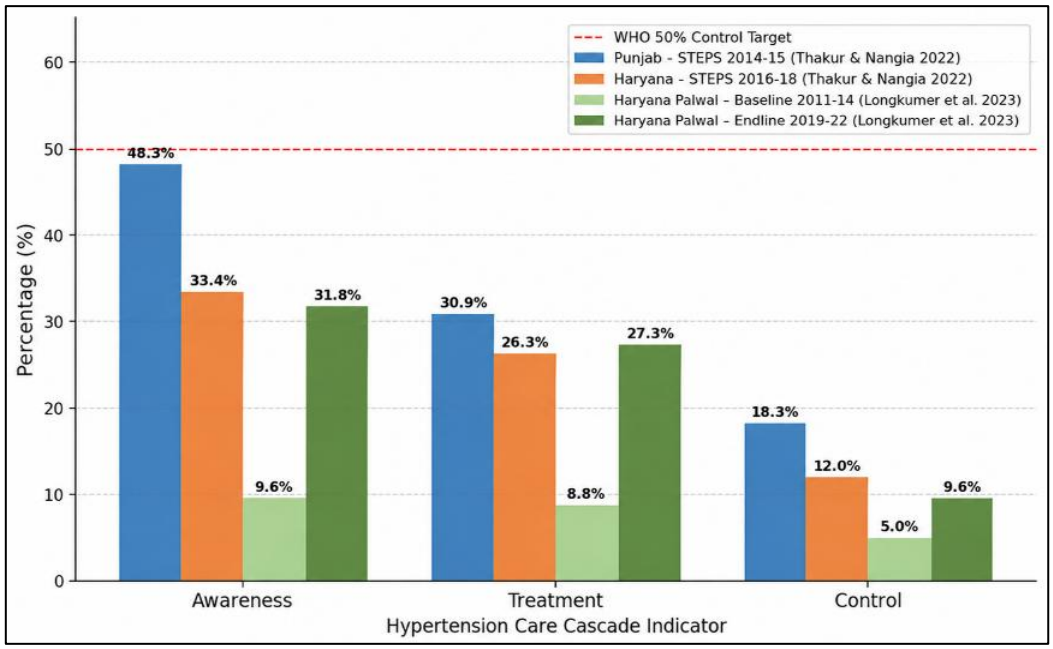

Figure 2: Hypertension ATC rates in Punjab and Haryana (2021-2026).

DISCUSSION

Magnitude and trends in prevalence

This systematic review documents a sustained upward trajectory in hypertension prevalence across both Punjab and Haryana. The state-wide STEPS survey (Thakur and Nangia 2022) remains the most methodologically robust estimate for both states, placing Punjab at 40.1% and Haryana at 26.2%.[8] The wide range observed in Punjab, from 24.3% (Jaacks et al) to 62% (Singh et al) reflects genuine differences in study populations, age ranges, urban/rural mix, and diagnostic criteria applied, rather than contradictions.[12,14]

In Haryana, the prospective cohort by Longkumer et al provides uniquely valuable evidence: it demonstrates a statistically significant increase in prevalence from 34.4% to 40.4% over eight years (p=0.002). This is not a cross-sectional artefact; it reflects genuine population-level blood pressure elevation as the cohort ages and as lifestyle transitions progress.[9] The simultaneous rise in median SBP from 120 mmHg to 125.5 mmHg in the entire cohort, including normotensives, is equally important.

The 48.6% prevalence among Faridabad industrial workers (Yadav et al) is the highest documented in any occupational group from Haryana and highlights a critically neglected subgroup facing compounding occupational risks.[16]

District-level heterogeneity

The NFHS-5-based ecological analysis by Pedgaonkar and Kumar documents substantial district-level clustering: Amritsar records the highest household hypertension clustering nationally at 37.3%, while Bathinda, Hoshiarpur, and Shahid Bhagat Singh Nagar all exceed 20%.[25] In Haryana, Kurukshetra similarly exceeds 20% household clustering. District-specific intervention strategies are more efficient than uniform state-wide programmes in such scenarios.

Risk factor profile: modifiable and non-modifiable factors

The risk factors documented in the current review period are consistent with findings from the prior systematic review (Sekhon et al).[11]

Non-modifiable risk factors

Increasing age was the most consistently reported non-modifiable risk factor across all studies in both Punjab and Haryana. Male sex was associated with higher prevalence at population level (Punjab: 47.4% vs. overall 40.1%; Haryana: 29.5% vs. overall 26.2%), though an age-related sex reversal was observed in elderly populations (Gupta et al. 2020: females 53.3% vs. males 46%).[8,26] Family history of hypertension was reported as a significant predictor in Mitra et al and Silan et al.[13,19]

Modifiable risk factors-dietary and metabolic

Obesity remains the most consistently documented modifiable risk factor. Vashist et al found that BMI ≥30 kg/m² was associated with a hypertension prevalence of 44%, and salt intake >20 g/day with 38%.[17] Dyslipidaemia (elevated cholesterol, triglycerides, LDL-C) was independently significant in Yadav et al among industrial workers.[16] Diabetes mellitus was confirmed as a co-morbid risk factor across multiple studies in both states.

Modifiable risk factors-behavioural

Tobacco use (smoking and smokeless tobacco) and alcohol consumption were consistently identified in both states. Physical inactivity and sedentary behaviour were documented by Jaacks et al, Mitra et al and Sindwani et al.[12,13,21] Psychological stress, anxiety, and depression were significant predictors in Fatehgarh Sahib (Shergill et al) and Gurugram (Vashist et al).[17,20]

Novel epigenetic factor

The most scientifically novel finding is global DNA hypomethylation as a biological correlate of hypertension in rural Punjab (Kaushik et al): hypertensives had significantly lower 5mC levels (0.65 vs. 0.72; p=0.01), with 1.67 times higher odds in the lowest methylation quartile (95% CI: 1.206-2.315; p=0.01). This implicates nutritional epigenetics, particularly folate metabolism, in hypertension pathogenesis in this region.[15]

Awareness, treatment, and control gap

Punjab's control rate of 18.3% and Haryana's of 12% (Thakur and Nangia) are far below the WHO 80-80-80 target.[8] Longkumer et al demonstrated that even over an 8-year period, control improved only from 5.0% to 9.6%, indicating that awareness campaigns alone are insufficient without structural health system improvements.[9] The IHCI has made progress in Punjab through decentralisation of hypertension care to Health and Wellness Centres in Bathinda and Hoshiarpur (Kaur et al), standardised drug and dose protocols (Kaur et al), and structured care pathways (Chavan et al), but population-level control rates remain well below targets. Earlier STEPS surveys from North India similarly documented persistently low ATC rates, indicating a long-standing systemic gap.[22-24,27]

Gender dimensions

Male predominance in hypertension prevalence was confirmed by the state-wide STEPS surveys.[8] However, Mitra et al found near-identical rates in Amritsar (males 34.4%, females 32.8%), and Gupta et al from Ballabgarh found higher female prevalence (53.3%) in the elderly (60-75 years) cohort.[13,26,28] This age-related sex reversal, driven by post-menopausal hormonal changes, necessitates sex-specific and age-stratified prevention strategies.

Comparison with national data

Punjab's STEPS-documented prevalence of 40.1% substantially exceeds the national NFHS-5 estimate. Mohammad and Bansod place Punjab at 34.2% nationally, the second-highest behind Sikkim (37.9%).[29] The disparity between STEPS and NFHS-5 estimates partly reflects differences in diagnostic protocol and age ranges covered (NFHS-5 includes age 15-49 only for blood pressure measurement, a younger group with lower burden). Earlier STEPS surveys from Punjab (2016) and Haryana (2019) had already documented NCD risk factor profiles consistent with high hypertension burden, confirming that the current elevated prevalence is part of a longer epidemiological trajectory rather than a recent phenomenon.[4,30,31]

Nationally, hypertension awareness, treatment, and control rates remain critically inadequate across India, as documented by large cohort analyses and systematic reviews; the findings from Punjab and Haryana are consistent with this national pattern.[10,32,33]

Limitations

Although this review provides an updated synthesis of hypertension research in Punjab and Haryana, the findings are limited by heterogeneity in study methodologies, populations, and outcome measurements. Publication bias cannot be completely excluded, as only published peer-reviewed studies were included. In addition, the limited availability of longitudinal and district-specific data may have restricted the assessment of temporal trends and regional variations.

CONCLUSION

This systematic review of hypertension in Punjab and Haryana from 2021 to 2026 identifies several critical findings. First, hypertension prevalence continues its

upward trajectory in both states: in Punjab, state-wide STEPS data document 40.1% overall prevalence (males 47.4%), while NFHS-5-based analysis places Punjab at 34.2%, the second-highest nationally. In Haryana, state-wide prevalence was 26.2% (males 29.5%) in the STEPS survey, rising to 40.4% in the 8-year rural cohort. The highest prevalence was recorded in industrial workers in Faridabad at 48.6%. Second, the only prospective cohort study from the region (Longkumer et al Haryana) provides unambiguous evidence of a statistically significant temporal increase (34.4% to 40.4%, p=0.002).[9] Third, district-level heterogeneity is marked, with Amritsar recording 37.3% household clustering, the highest nationally. Fourth, awareness, treatment, and control rates remain critically inadequate despite IHCI expansion, with control at 18.3% in Punjab and 12% in Haryana. Fifth, the established modifiable risk factor profile persists, with a novel epigenetic correlate (global DNA hypomethylation) identified in rural Punjab for the first time.

Recommendations

Urgently expand IHCI to all districts of Punjab and Haryana with standardised treatment protocols, assured drug supply, and digital patient tracking at the Health and Wellness Centre level. Commission large-scale, district-representative studies in underrepresented districts of both states. Implement targeted occupational hypertension screening for industrial workers in the Faridabad-Gurugram corridor of Haryana. Scale up community-level dietary salt reduction and obesity prevention campaigns. Explore nutritional epigenetics-based interventions, including folate supplementation programmes in rural Punjab. Integrate screening for anxiety and depression into hypertension management protocols, particularly for women. Conduct prospective cohort studies with repeated blood pressure measurements and biomarker panels to generate causal evidence on risk factors, including epigenetic markers.

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