Hypertension treatment cascade among men and women of reproductive age group in India: analysis of National Family Health Survey-5 (2019–2021)

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Summary

Background Only a proportion of adults with hypertension are diagnosed and receive recommended prescriptions despite the availability of inexpensive and efficacious treatment. We aimed to estimate the prevalence of different stages of hypertension treatment cascade among the reproductive age groups in India at the national and state levels. We also identified the predictors of different stages of the hypertension treatment cascade.

Methods We used the nationally representative data from National Family Health Survey (NFHS)-5. We included all the males (15–54 years) and females aged 15–49. Socio-demographic factors, anthropometric measurements, habits, comorbid conditions, and healthcare access stratified the stages of the hypertension treatment cascade among hypertensives. We used multinomial logistic regression to identify the determinants of the treatment cascade levels.

Findings We had data from 1,267,786 individuals. The national prevalence of hypertension was 18.3% (95% CI: 18.1%–18.4%). Men (21.6%, 95% CI: 21.5%–21.7%) were found to have a higher prevalence as compared to women (14.8%, 95% CI: 14.7%–14.9%). Among hypertensive individuals, 70.5% (95% CI: 70.3%–70.7%) had ever received a BP measurement ("screened"), 34.3% (95% CI: 34.1%–34.5%) had been diagnosed prior to the survey ("aware"), 13.7% (95% CI: 13.5%–13.8%) reported taking a prescribed anti-hypertensive drug ("under treatment"), and 7.8% (95% CI: 7.7%–7.9%) had their BP under control ("controlled"). Males, illiterates, poor, never married, residents of rural areas, smokers/tobacco users, and alcoholic users were less likely to be in any of the treatment cascades.

Interpretation The prevalence of hypertension in India is high. The "Rule of half" of hypertension does not apply to India as the proportion of people screened, aware of their hypertension status, treated, and controlled are lower than 50% at each stage. Program managers must improve access to hypertension diagnosis and treatment, especially among men in rural areas and populations with lower household wealth.

Funding None.

Keywords: Hypertension; Screening; Rule of half; Secondary data; Large survey

Introduction

India is experiencing a rapid rise in non-communicable diseases (NCDs), despite its high burden of infectious diseases and maternal and child health issues.[1] Hypertension is one of the significant risk factors for preventable and premature deaths globally. Only a proportion of adults with hypertension are diagnosed and receive recommended treatment despite the availability of inexpensive and efficacious treatment.[2] Worldwide awareness, diagnosis, and treatment coverage among adults have been reported as 46%, 42%, and 21%, respectively. This gap in the management of hypertension is one of the critical reasons for the increased prevalence of hypertension in low-and middle-income countries, especially in South Asia.[3]

In India, Cardiovascular Diseases (CVDs) account for nearly half of the deaths due to non-communicable diseases (NCDs).[4] This is further accentuated by a lack

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Research in context

Evidence before this study

- Hypertension is a significant risk factor for cardiovascular disease, India's leading and preventable cause of death.
- Researchers have utilized the treatment or care cascade for some chronic diseases as a valuable tool to assess the health system's performance and plan newer strategies. The 'cascade' consists of the proportion screened for a particular chronic illness, are aware of their diagnosis, are on appropriate treatment, and have the condition under control.

Added value of this study

- To date there are limited large-scale population-based studies in India showing updates in the transition stages from screening to successful control of hypertension, at which people are either lost from care or never enrolled.
- Unlike the previous authors who have published findings on hypertension care cascade, we presented the results from the large nationally representative survey of India, National Family Health Survey-5, 2019–2021 on the prevalence and determinants of stages of hypertension treatment cascade which can be a valid tool to assess health system performance, the usefulness of previous interventions and plan newer strategies.

Implications of all the available evidence

- Proportion of adults with hypertension in India who are aware of their diagnosis, are on treatment and have controlled blood pressure is low.
- As the hypertension treatment cascade was stratified for states, this study will help policy-makers select target groups and design appropriate interventions to improve hypertension care in India.
- While improvements are needed for all stages of the hypertension treatment cascade, this analysis showed that a higher focus is required in the current public health interventions on this population to increase the awareness and diagnosed patients to improve their likelihood of sustaining treatment of hypertension.
- The findings will enable the achievement of the Sustainable Development Goals (SDG) target of reducing premature mortality from NCDs by one-third by 2030 and the NCD target of a 25% reduction of raised blood pressure by 2025.

of appropriate care and management, poor follow-up, and low levels of awareness among people.[5] Due to the multi-factorial causation of hypertension, improving the quality of care throughout the continuum from early diagnosis to screening for complications of hypertension is critical to reducing premature mortality. The global NCD action plan targets to achieve a 25% relative reduction in the prevalence of high blood pressure among persons aged 18 years and above by 2025.[6] In order to achieve the Sustainable Development Goals (SDG) target of reducing premature mortality from NCDs to one-third by 2030,[7] India has recently strengthened its strategy by launching population-based screening for hypertension (along with diabetes and the three common cancers) and strengthening primary and secondary health facilities.[8]

Understanding the stages of hypertension "treatment cascade" is a valuable tool to assess health system performance and previous interventions' usefulness and plan newer strategies. Stages of the hypertension treatment cascade include the proportion of people screened for hypertension, aware of their diagnosis, on appropriate treatment, and with their blood pressure under control. The fourth National Family Health Survey (NFHS) of India conducted in 2015–2016 showed hypertension prevalence was 18.1% among adults aged 15–49. The screening happened for only three-fourths (76.1%) of all eligible participants, while the diagnosis was available for less than half (44.7%). 13% reported continuing treatment, while a mere 7.9% had blood pressure controlled.[9] The first national-level NCD survey conducted in 2018–2019 reported the prevalence of hypertension as 28.5% among the population aged 18–49. The survey reported that 27.9%, 14.5%, and 12.6% of those suffering from hypertension were aware, on treatment, and with blood pressure controlled.[10]

A few years after the launch of NPCDCS, reports have claimed significant success in the scale-up of hypertension screening in India. India Hypertension Control Initiative (IHCI) was launched with support from the Indian Council of Medical Research and the World Health Organization (WHO) to buttress this claim.[8,11] In line with the utility of such surveys in understanding the impact of various interventions and strategies on the prevalence of hypertension, decision-making, and policy formulations, the present study aimed to determine the proportion of reproductive-age adults in India in various levels of hypertension treatment cascade at the state and the national levels by using the most recent NFHS-5 survey conducted in 2019–2021.[12] We also intended to identify the predictors of presence in different stages of hypertension treatment cascade (such as socio-demographic factors, anthropometric measurements, habits, comorbid conditions, and health care access).

Methods

Data source

We used National Family Health Survey (NFHS-5) data from 2019 to 2020. NFHS-5 was a household survey that covered each district in all 29 states and seven union territories of India. It was conducted under the aegis of the Ministry of Health and Family Welfare (MoHFW), coordinated by the International Institute for Population Sciences (IIPS), Mumbai, and implemented by a group of survey organizations and Population Research Centres. Technical assistance for NFHS-5 was provided by the International Classification of Functioning, Disability and Health (ICF), USA, with financial support from US Agency for International Development (USAID).[12]

NFHS-5 has adopted a uniform sample design, representing national, state/union territory, and district levels. It used a two-stage cluster sampling approach wherein, in the first stage, primary sampling units (PSUs), i.e., villages in rural areas and census enumeration blocks (CEBs) in urban areas, were selected using the probability proportional to size (PPS) technique.[13] A list of households was created by mapping and household listing in each selected PSU. In the second stage, researchers selected a fixed number of 22 households per cluster (i.e., PSUs) using an equal probability systematic selection.[12]

Variables considered for the study

Dependant variables

Our primary outcome of interest was hypertension treatment cascades with one of the four options: "Screened," "Aware," "On treatment," and "Under control." The secondary outcome was the prevalence of hypertension.

In NHHS-5, three blood pressure (BP) readings were taken from participants at least 5 min between each BP measurement with a standardized OMRON™ BP monitor. We have considered the average of all three blood pressure readings to decide whether a participant was hypertensive. If one measurement was missing for an individual in the dataset, then the average of the remaining two measurements was used. We used the remaining measurement if two measurements were missing. WHO considers a person to be suffering from hypertension if the systolic blood pressure is ≥140 mmHg with or without diastolic blood pressure ≥90 mmHg, or if the individual has been currently using anti-hypertensive medication to lower the blood pressure, or if a doctor or other health professionals in the past identified high BP on two or more occasions.[14,15] We calculated the prevalence of hypertension by adding the above proportions. We considered them "screened" if they answered yes to the question, "Before this survey, has your blood pressure ever been checked?". We included them in the stage "Aware" if they responded affirmative to either currently using anti-hypertensive medication to lower the blood pressure or if a doctor or other health professionals in the past identified high BP on two or more occasions. Similarly, we have included the individuals in the "On treatment" stage if they self-reported using anti-hypertensive medication to lower blood pressure. Hypertension "Under control" has been defined for individuals with hypertension who are currently using anti-hypertensive medication and have systolic blood pressure (SBP) <140 mmHg and diastolic BP (DBP) <90 mmHg. The denominator to calculate all stages of the treatment cascade was the number of individuals having hypertension.

Independent variables

We considered independent or predictor variables according to the following broad domains.

Socio-demographic variables. Age, sex, marital status, caste, region (rural/urban), religion, type of family, type of house, wealth index, education and place of residence, region of the country (High focus states: Bihar, Chhattisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, and Uttar Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. Non-high focus states: Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Punjab, Tamil Nadu, Telangana and West Bengal, Andaman & Nicobar Islands, Chandigarh, Dadra & Nagar Haveli, Daman & Diu, Delhi, Ladakh, Lakshadweep and Puducherry).[16]

Anthropometric indicators. High waist circumference (cut-off values 90 cm for men and 80 cm for women), high waist-hip ratio (cut-off value 0.95 for men and 0.85 for women),[17] levels of BMI (underweight, normal, overweight, and obese calculated by using formula Weight in Kg/Height in m^2) with Asian population cut-offs of <18.5, 18.5–22.9 and ≥23[17] and international standard cut-offs of <18.5, 18.5–24.9 and ≥25.[18]

Habits. We have included smoking/tobacco consumption, alcohol consumption, and using iodized salt as habits.

Comorbid conditions. The presence of diabetes mellitus (diagnosis of diabetes is by fasting plasma glucose and post-prandial plasma glucose of 126 mg/dl and 200 mg/dl respectively[17] or had been told to have high plasma glucose on two or more occasions by a doctor or other health professionals or currently taking prescribed medicine to lower blood glucose), ever screened for diabetes, history of tuberculosis, and presence of anemia, ever screened for cervical, breast or oral cavity cancers.

Healthcare access. Factors are health insurance coverage and the sources of healthcare.

Data analysis

We accessed the household member-recoded file with individual-level data from the Demographic and Health Surveys (DHS) program.[19] The proportions of screened, aware, on treatment, and under control among individuals with hypertension in the age group of 15–49 years for women and 15–54 years for men, along with 95% confidence intervals (95% CI), has been estimated.

We conducted a sensitivity analysis to obtain the prevalence of the outcomes by including the mean of all three or two (second and third) blood pressure measurements. For all subsequent analyses, we used the mean of all three measurements. If one measurement was missing for an individual in the dataset, then the average of the remaining two measurements was used. We used the remaining measurement if two measurements were missing. We assessed the association between socio-demographic factors, anthropometric indicators, habits, comorbid conditions, and healthcare access with the outcome through bivariate analyses. The multinomial logistic regression included all the associations with a statistically significant p-value of <0.05 on bivariate analyses. We have used a 10% cut-off for missing data on each variable to consider inclusion in the final analysis. The total percentage of missing cases in the final analysis, was 4.8%. We used IBM SPSS Statistics for Windows, Version 26.0 (Armonk, NY: IBM Corp.) for all these analyses.

Role of funding source

Not applicable.

Results

Sample characteristics

Data from 2,843,917 individuals (household member recode file IAPR7CFL) was available. We have included 1,267,786 records in our final analysis (Fig. 1).

The number of males (n = 9,639,482, 50.4%) and females (n = 628,304, 49.6%) were almost equal in the sample. Almost half of them (n = 669,475, 52.8%) were more than 30 years of age and had completed secondary school (n = 699,605, 55.2%), were living in pucca houses (n = 691,141, 55.3%) and had nuclear families (n = 642,583, 50.7%). 68.8% (n = 872,483) were married, with the majority being Hindus (n = 954,918, 75.3%). Three-fourths of the participants were from rural areas (n = 953,516, 75.2%), with around 41% belonging to 'scheduled' castes and 'scheduled' tribes. 63% (n = 798,981) were from high-focus states as defined by National Health Mission (NHM).[16]

Hypertension treatment cascade at the national level

The national prevalence of hypertension in the sampled age group was 18.3% (95% CI: 18.1%–18.4%) and 16.3% (95% CI: 16.2%–16.4%), with three and two blood pressure measurements, respectively. Among hypertensives, 70.5% (95% CI: 70.3%–70.7%) had their BP measured ("screened") ever, 34.3% (95% CI: 34.1%–34.5%) had been diagnosed before the survey ("aware"), 13.7% (95% CI: 13.5%–13.8%) reported taking a prescribed anti-hypertensive drug ("on treatment"), and only 7.8% (95% CI: 7.7%–7.9%) had their BP under control ("under control").

Men (21.6%, 95% CI: 21.5%–21.7%) had a somewhat higher prevalence of hypertension as compared to women (14.8%, 95% CI: 14.7%–14.9%). The relative differences between screening to awareness, awareness to treatment, and treatment to control stage were 51.4%, 60%, and 43.1%, respectively. Women were more likely to reach each stage of the treatment cascade. Among male hypertensives, the relative difference between screening to awareness was 58.9%, awareness to treatment was 54.5%, and treatment to control stage was 51.2%. Similar values were 42.1%, 64.9%, and 32.9%, respectively, for females (Fig. 2).

Determinants of the hypertension treatment cascade

Table 1 shows the prevalence of the four stages of hypertension treatment cascade across various socio-demographic and geographical characteristics in India. The screening was more likely to be conducted among those aged ≥30 years, having higher education, married or living together, caste other than SC/ST/OBC, residing in urban areas, most affluent wealth group, Muslim population, staying in a nuclear family, living in a pucca house, and residing in one of the non-high focus states. However, on multivariate analysis (Supplementary Table S2a), individuals with higher education status, married and living together, wealth index of the richest, and living in high-focus states remained significantly more likely to be screened for hypertension. In the multivariate analysis, screening was more common among individuals in the 19–29 age group. Females were added up in multivariate analysis as more likely to be screened. Similarly, in the descriptive analysis, participants of age 19–29 years, higher education status, married and living together, caste other than SC/ST/OBC, residents of urban areas, being in the wealthiest wealth index, Muslim, non-nuclear family, residing in a pucca house and belong to high focus states were more aware of their hypertensive status before this survey. During multivariate analysis, females, higher education status, married and living together, wealth index of richest, other religions (other than Hindu, Muslim, and Christians), individuals with non-nuclear families, living in high focus states had significantly higher awareness regarding their hypertension status. Participants belonging to Scheduled Tribes were less likely to be aware. Place of residence and type of house had no significant effect on awareness (Supplementary Table S2a).

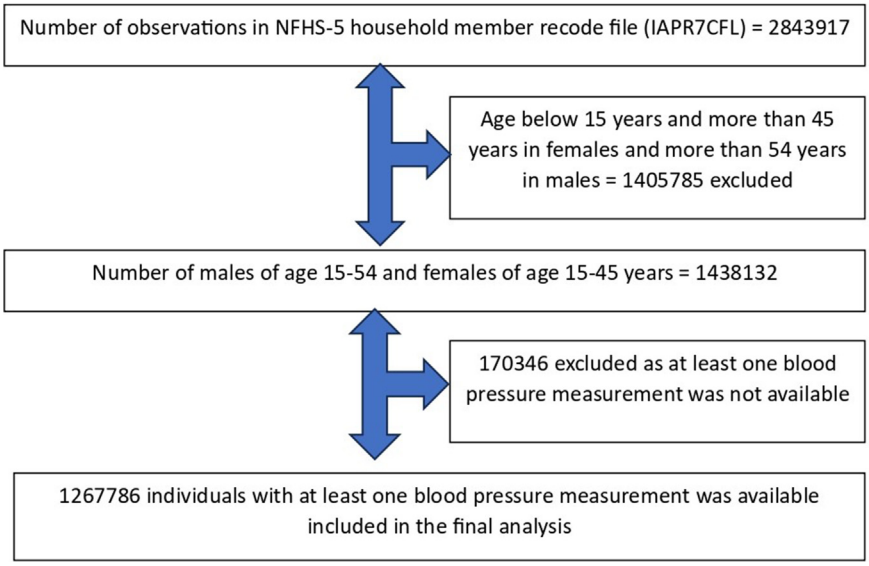

Fig. 1: **Sampling strategy adopted in NFHS 5.**

Initially, individuals of age 15–18 years, with higher education status, caste other than SC/ST/OBC, residents of urban areas, being in the richest wealth index, Muslim, living in a pucca house, and belonging to non-high-focus states were more likely to be on both on treatment for hypertension and having BP under control on bivariate analysis. On regression, females from another caste, Christians living in non-high-focus states, were found to have significantly higher treatment rates. Marital status, education status, wealth index, place of residence, household structure, and type of house had no significant effect on treatment status for hypertension. More than 30 years age group, divorced/widowed/not living together were less likely to have their BP controlled. In contrast, female sex, higher education status, and non-nuclear families were associated with BP control (Supplementary Table S2a).

Table 2 shows the distribution of hypertension treatment cascade stages across various anthropometric indicators, habits, comorbid conditions, and healthcare access. The higher screening was reported by those with high WC, WHR, and BMI (Asian classification), non-smokers, alcohol non-users, using iodized salt; with comorbid conditions like diabetes, tuberculosis, and anemia, previously screened for diabetes and cancer,

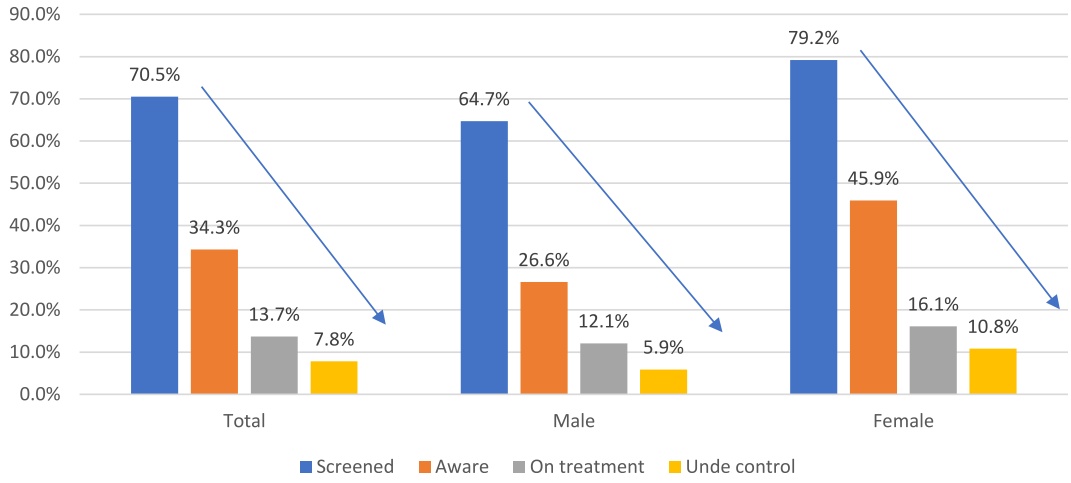

Fig. 2: **Prevalence of hypertensive Indian adults screened, aware, on treatment, and under control, NFHS-5, 2019–2020 (n = 231,373).**

Variable	Hypertensives[a]	Screened (S) (%, 95% CI)	Aware (A) (%, 95% CI)	On treatment (T) (%, 95% CI)	Under control (C) (%, 95% CI)
Age group					
15–18 years	7519	43.6 (42.5–44.7)	36.6 (35.5–37.7)	15.7 (14.9–16.6)	14.7 (14.9–16.6)
19–29 years	50,240	65.3 (64.9–65.8)	38.0 (37.5–38.4)	11.2 (10.9–11.5)	9.4 (9.2–9.7)
>30 years	173,118	73.2 (73.0–73.4)	33.2 (32.9–33.4)	14.4 (14.2–14.5)	7.1 (6.9–7.2)
Education status					
No education	43,132	66.9 (66.4–67.3)	33.1 (32.6–33.5)	12.8 (12.5–13.1)	7.4 (7.2–7.7)
Primary	32,476	68.6 (68.0–69.1)	32.1 (31.6–32.6)	13.4 (13.1–13.8)	7.3 (7.0–7.6)
Secondary	119,888	70.9 (70.6–71.1)	34.7 (34.4–34.9)	14.0 (13.8–14.2)	8.0 (7.8–8.2)
Higher	35,266	75.7 (75.3–76.2)	36.8 (36.3–37.3)	14.1 (13.8–14.5)	8.2 (7.9–8.6)
Marital status					
Never married	33,633	53.9 (53.4–54.5)	29.4 (28.9–29.9)	11.3 (10.9–11.3)	9.1 (8.9–9.5)
Married/living together	189,419	73.4 (73.2–73.6)	35.2 (35.0–35.4)	14.1 (13.9–14.2)	7.6 (7.5–7.8)
Divorced/widowed/not living together	7814	73.4 (72.4–74.3)	34.3 (33.2–35.3)	16 (15.2–16.8)	7.7 (7.2–8.4)
Caste					
SC	45,118	70.9 (70.5–71.4)	34.9 (34.5–35.4)	12.6 (12.3–12.9)	7.3 (7.1–7.5)
ST	46,079	62.0 (61.5–62.4)	28.8 (28.4–29.2)	11.5 (11.2–11.8)	6.6 (6.4–6.8)
OBC	82,939	71.7 (71.4–72.0)	34.6 (34.3–34.9)	13.5 (13.3–13.7)	7.7 (7.5–7.9)
Others	47,642	76.2 (75.8–76.6)	37.7 (37.3–38.1)	16.0 (15.7–16.3)	8.8 (8.6–9.2)
Place of residence					
Urban	62,541	77.4 (77.1–77.7)	36.2 (35.8–36.6)	16.1 (15.8–16.4)	8.3 (8.1–8.6)
Rural	168,325	68.0 (67.8–68.2)	33.6 (33.4–33.9)	12.8 (12.7–12.9)	7.6 (7.5–7.7)
Wealth index					
Poorest	41,440	57.9 (57.4–58.4)	30.7 (30.3–31.2)	11.0 (10.7–11.3)	7.6 (7.3–7.9)
Poorer	47,949	66.1 (65.7–66.6)	33.4 (32.9–33.8)	12.2 (11.9–12.5)	7.5 (7.3–7.8)
Middle	48,879	71.5 (71.1–71.9)	33.8 (33.4–34.3)	13.4 (13.1–13.7)	7.5 (7.3–7.8)
Richer	47,931	75.5 (75.1–75.9)	35.5 (35.1–35.9)	15.2 (14.9–15.5)	8.0 (7.8–8.3)
Richest	44,667	80.7 (80.3–81.1)	38.0 (37.6–38.5)	16.6 (16.3–16.9)	8.5 (8.2–8.7)
Religion					
Hindu	170,420	69.3 (69.0–69.5)	32.9 (32.7–33.1)	13.0 (12.9–13.2)	7.5 (7.4–7.7)
Muslim	25,340	76.2 (75.6–76.7)	41.0 (40.4–41.6)	18.6 (18.1–19.1)	10.8 (10.5–11.3)
Christian	18,506	70.1 (69.4–70.7)	34.8 (34.1–35.5)	14.9 (14.4–15.4)	8.7 (6.0–8.4)
Others	16,600	75.8 (75.2–76.5)	38.5 (37.8–39.3)	11.9 (11.4–12.4)	5.8 (5.5–6.2)
Type of family					
Nuclear	123,368	71.0 (70.7–71.2)	33.8 (33.5–34.0)	14.1 (13.9–14.3)	7.8 (7.6–7.9)
Non-nuclear	107,498	70.1 (69.8–70.4)	35.0 (34.7–35.3)	13.3 (13.1–13.5)	7.9 (7.8–7.1)
Type of house					
Kucha	12,252	60.7 (59.8–61.6)	33.3 (32.5–34.2)	11.2 (10.6–11.7)	7.6 (7.1–8.1)
Semi pucca	84,264	65.7 (65.4–66.1)	33.5 (33.2–33.8)	11.9 (11.7–12.1)	7.3 (7.2–7.5)
Pucca	131,268	74.7 (74.4–74.9)	35.0 (34.7–35.2)	15.1 (14.9–15.3)	8.2 (8.0–8.3)
Region of country					
Non-high-focus states	87,310	74.5 (74.2–74.8)	31.8 (13.5–32.1)	15.6 (15.4–15.9)	8.2 (8.0–8.4)
High focus states	143,556	68.1 (67.9–68.4)	35.9 (35.6–36.1)	12.5 (12.4–12.7)	7.6 (7.5–7.7)

SC: Scheduled Caste; ST: Scheduled Tribe; OBC: Other Backward Classes; NHM: National Health Mission. High focus states: Bihar, Chhattisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Odisha, Rajasthan, and Uttar Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. Non-high focus states: Andhra Pradesh, Goa, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Punjab, Tamil Nadu, Telangana and West Bengal, Andaman & Nicobar Islands, Chandigarh, Dadra & Nagar Haveli, Daman & Diu, Delhi, Ladakh, Lakshadweep, and Puducherry. [a]Missing values were excluded from the analysis.

Table 1: **Socio-demographic characteristics across stages of hypertension treatment cascade in India (NFHS 5, 2019–2020).**

without health insurance coverage and utilizing private health facilities. People having high WC/WHR, underweight, non-smokers, alcohol non-users, iodized salt users, having comorbid conditions like diabetes, tuberculosis, and anemia, without health insurance coverage, and utilizing private health facilities reported higher awareness of their hypertension diagnosis. Better treatment was more likely for those with higher WC/WHR/BMI, alcohol non-users, those using iodized salt; having comorbid conditions like diabetes, tuberculosis, and

Variable	Hypertensives[a]	Screened (S) (%, 95% CI)	Aware (A) (%, 95% CI)	On treatment (T) (%, 95% CI)	Under control (C) (%, 95% CI)
Anthropometric indicators and habits					
Waist circumference					
Low	56,175	71.1 (70.7–71.5)	41.2 (40.8–41.6)	13.7 (13.4–13.7)	11.7 (11.5–12.0)
High	57,457	82.3 (82.0–82.6)	43.0 (42.6–43.4)	16.7 (16.4–17.0)	9.1 (8.9–9.4)
WHR					
Low	46,974	72.7 (72.3–73.1)	39.5 (39.1–39.9)	13.7 (13.4–14.0)	9.3 (9.1–9.6)
High	66,627	79.6 (79.3–79.9)	43.9 (43.6–44.3)	16.3 (16.0–16.6)	9.8 (9.6–10.1)
BMI (Asian criteria)					
<18.5 kg/m^2	9929	70.4 (69.5–71.3)	49.3 (48.3–50.3)	16.2 (15.5–16.9)	13.8 (13.2–14.6)
18.5–22.9 kg/m^2	33,197	75.6 (75.2–76.1)	46.9 (46.4–47.5)	14.8 (14.4–15.1)	11.3 (10.9–11.6)
≥23 kg/m^2	49,680	83.4 (83.1–83.7)	44.5 (44.0–44.9)	17.0 (16.7–17.3)	9.5 (9.2–9.7)
BMI (international criteria)					
<18.5 kg/m^2	9929	70.4 (69.5–71.3)	49.3 (48.3–50.3)	16.2 (15.5–16.9)	13.8 (13.2–14.6)
18.5–24.9 kg/m^2	48,418	77.1 (76.7–77.4)	46.0 (45.5–46.4)	14.8 (14.5–15.1)	10.7 (10.4–10.9)
≥25 kg/m^2	34,459	84.8 (84.4–85.2)	44.7 (44.2–45.2)	17.9 (17.5–18.3)	9.5 (9.2–9.9)
Smokes/uses tobacco					
Yes	71,989	64.3 (63.9–64.6)	27.6 (27.3–27.9)	11.8 (11.6–12.0)	5.8 (5.7–6.1)
No	158,703	73.4 (73.2–73.6)	37.4 (37.2–37.6)	14.6 (14.4–14.8)	8.7 (8.6–8.9)
Alcohol consumption					
Yes	46,303	64.9 (64.4–65.3)	25 (24.6–25.4)	10.9 (10.7–11.2)	4.6 (4.4–4.8)
No	184,345	72.0 (71.8–72.2)	36.7 (36.5–36.9)	14.4 (14.3–14.6)	8.6 (8.5–8.7)
The iodine content of salt					
Iodine present	220,072	70.8 (70.6–80.0)	34.4 (34.2–34.6)	13.7 (13.6–13.9)	7.8 (7.7–7.9)
Iodine absent	10,205	65.2 (64.2–66.1)	32.6 (31.7–33.5)	13.3 (12.6–13.9)	8.3 (7.7–8.8)
Comorbid conditions					
Diabetes					
Yes	19,883	88.6 (88.1–89.0)	62.7 (62.1–63.4)	24.7 (24.1–25.3)	11.8 (11.3–12.2)
No	200,464	68.6 (68.4–68.8)	31.3 (31.1–31.5)	12.2 (12.1–12.4)	7.8 (7.7–7.9)
Ever screened for diabetes					
Yes	77,875	93.9 (93.7–94.1)	42.0 (41.7–42.4)	18.3 (18.0–18.5)	9.6 (9.4–9.8)
No	141,838	57.5 (57.2–57.7)	29.7 (29.5–30.0)	10.6 (10.5–10.8)	7.3 (7.2–7.5)
History of tuberculosis					
Yes	621	72.6 (68.9–76.1)	40.4 (36.5–44.4)	17.4 (14.5–20.6)	11.1 (8.8–13.9)
No	230,245	70.5 (70.4–70.7)	34.3 (34.1–34.5)	13.7 (13.6–13.8)	7.8 (7.7–7.9)
Anaemia					
Yes	45,841	79.3 (78.9–79.7)	48.8 (48.4–49.3)	17.1 (16.7–17.4)	12.3 (12.0–12.6)
No	43,234	79.1 (78.7–79.5)	42.8 (42.4–43.3)	14.5 (14.1–14.8)	9.5 (9.2–9.7)
Ever screened for common cancers					
Yes	2387	84.0 (82.4–85.4)	48.1 (46.0–50.1)	21.2 (19.6–23.0)	11.5 (10.2–12.8)
No	117,166	76.3 (76.1–76.6)	41.8 (41.5–42.0)	15.4 (15.2–15.6)	9.1 (8.9–9.3)
Health care access					
Health insurance coverage					
Yes	98,602	70.1 (69.9–70.4)	32.8 (32.5–33.1)	14.3 (14.1–14.5)	8.0 (7.9–8.2)
No	131,149	70.8 (70.6–71.1)	35.5 (35.2–35.7)	13.3 (13.1–13.5)	7.7 (7.5–7.8)
Type of healthcare access					
Government/public	132,827	69.4 (69.2–69.7)	33.0 (32.7–33.2)	13.8 (13.6–14.0)	7.8 (7.7–8.0)
Private	95,544	72.1 (71.8–72.4)	36.1 (35.8–36.4)	13.6 (13.4–13.8)	7.8 (7.7–8.0)
Home treatment	2495	70.0 (69.2–71.8)	34.9 (33.0–36.8)	12.8 (11.5–14.2)	7.4 (6.4–8.5)

BMI: Body mass index; WHR: Waist hip ratio-Low: <0.95 (men)/<0.85 (Women), High: ≥0.95 (men)/≥0.85 (Women), Waist circumference-Low: <90 cm (men)/<80 cm (Women), High: ≥90 cm (men)/≥80 cm (Women). [a]Missing values were excluded from analysis.

Table 2: **Distribution of anthropometric indicators, habits, comorbid conditions, and health care access across different stages of hypertension treatment cascade in India (NFHS 5, 2019–2020).**

anemia; ever screened for diabetes and cancer, or with health insurance coverage and utilizing government/public health facilities.

Multivariate analysis shows that individuals with higher waist circumference, higher BMI, using iodized salt, screened for diabetes, diagnosed with anemia, screened for common cancers, and utilizing private health facilities were more likely to be screened for hypertension. In contrast, alcohol users were less likely to be screened. Participants with waist circumference, waist-hip ratio more than cut-off values, having higher BMI, and consuming alcohol were less likely to be aware of their diagnosis. Participants having diabetes, a history of tuberculosis, anemia, ever screened for diabetes and cancers, and utilizing private health facilities were found to be more aware of their diagnosis. Individuals who were smokers/tobacco users, using iodized salt, diabetics, ever screened for diabetes, had anemia, or had ever screened for common cancers were more likely to be treated for hypertension, and alcoholics were found to be less likely to the treatment of hypertension. Similarly, people with waist circumference and WHR more than the cut-off value, BMI more than 23 kg/m^2, tobacco users, alcoholics, and diabetics were less likely to have their BP controlled (Supplementary Table S2b).

Screening coverage among hypertensive individuals varied from 52.2% (95% CI: 50.6%–53.8%) in Meghalaya to 91.1% (88.2%–93.6%) in Goa and 95.7% (95% CI: 92.5%–97.7%) in Lakshadweep; awareness of diagnosis, from 19% (95% CI: 18.3%–19.8%) in Chhattisgarh to 57.9% (95% CI: 57.0%–58.9%) in Bihar; treated hypertension, from 7.8% (95% CI: 7.3%–8.4%) in Chhattisgarh to 26.8% (95% CI: 22.7%–30.8%) in Goa; and controlled hypertension, from 3.5% (95% CI: 2.9%–4.2%) in Nagaland to 18.7% (95% CI: 14.5%–22.9%) in Meghalaya (Supplementary Figure S1).

The prevalence of hypertension across various socio-demographic factors, anthropometric measurements, habits, comorbid conditions, and healthcare access was shown in Supplementary Table S1a and S1b. The absolute and relative differences between the distribution of the stages of hypertension treatment cascade across various socio-demographic factors, anthropometric measurements, habits, comorbid conditions, and healthcare access have been shown in Supplementary Table S1c and S1d. State and union territory-wise proportions of cascade stages are presented in Supplementary Table S2. Supplementary Figure S1 shows the variation among states and union territories in the proportion of those with hypertension who reached each stage of the treatment cascade.

Discussion

We report the treatment cascade analysis in the nationally representative sample of 1,267,786 individuals from the reproductive age group men (15–54 years) and women (15–49 years) in India. Similar analyses have been conducted for hypertension using data from NNMS in India as well as in other countries.[5,20] Treatment or care cascade studies have been reported for other diseases at the global level for HIV,[21] TB,[22] perinatal depression[23] and country level for HIV,[24] epilepsy,[25] chronic hepatitis-B disease,[26,27] chronic hepatitis-C disease,[27,28] etc. Treatment cascade analysis is a crucial proxy to identify attrition or treatment gaps and unmet needs of management of illnesses of public health importance, especially chronic diseases.[29] Estimates on predictors for attrition from various stages of care have been reported for various diseases and health conditions at global, national, and local levels.[30–32] Such evidence can benefit policy-makers and program managers to focus on the limited resources and improve the continuum of care. Authors have varied reported treatment or care cascade stages such as burden, access, screening or testing, diagnosis, initiation of treatment, receipt of medicine and non-pharmacological interventions, the continuation of treatment at variable duration after diagnosis, control of disease at variable durations after diagnosis, cure of disease, screening for complications, prevention of premature mortality, prevention from disability etc. Global and national-level action plans for hypertension target one or more stages of the treatment cascade.[33] Health policy and system researchers should evaluate hypertension service quality through a cascade-of-care approach with a standardized list of indicators.[34]

The prevalence of hypertension in India for the reproductive age-group men and women combined was 18.3% in 2019–2020. It has remained stable since 2014–2015 till now if we consider the data from NFHS.[9] However, we can see that the prevalence of hypertension was much higher at 28.5% in the NNMS conducted by the Indian Council of Medical Research (ICMR) in 2017–2018.[5] This might be due to the inclusion of 18–69 years age group. NNMS study was conducted 2–3 years earlier than NFHS-5. The health promotion strategies focusing on reducing behavioral risk factors and population-based screening seem to have achieved satisfactory output during the last 5–6 years. Another national-level household survey done in Sierra Leone, Africa, showed a higher prevalence of hypertension at 22%.[35] This starkly contrasted with a higher prevalence of 44.7% in the same study period in China obtained through an extensive national survey.[36] Prevalence of hypertension ranged from 30% to 40% in other international studies conducted using national-level data.[37–39] The National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Disease, and Stroke (NPCDCS) of India aims to conduct population-based screening of diabetes mellitus, hypertension, and the three common cancers for all women and men aged 30 years and above.[40] However, we found that 9.7% of individuals of 15–29 years were hypertensives, and by not

including this age group, 25% of hypertensives remained undiagnosed.

The prevalence of reproductive age-group adults in India screened for hypertension has also remained stable since NFHS-4 at around 76%. The highest absolute loss in the treatment cascade occurred at the awareness (36.2%) and screening stage (29.5%), while the highest relative loss occurred at the treatment stage (60%).[9] Of the hypertensives identified in NNMS, 27.9% were aware of their status, which is relatively lower than NFHS-5.[5] Difference in data collection methods may explain this difference. In the Sierra Leone study, 23% were aware of their diagnosis.[34] Lack of awareness regarding the diagnosis status reflects poorly on the private health system, where nearly 80% of people seek ambulatory care.[41] Awareness regarding their diagnosis ranged from 66% to 78% in other international studies.[37,38,42] Communication of diagnosis to patients has not received enough attention in the medical education system of India. Though the National Medical Commission (NMC) has developed the AETCOM (Attitude, Ethics & Communication) module to improve the communication skills of medical graduates, particular focus is required in the post-graduate training curriculum to teach risk communication techniques to specialists too.[43] Poor awareness of the diagnosis of hypertension also reflects on the efforts to achieve national targets of NPCDCS interventions in NCD clinics. There is a shortage of counselors in these clinics, and the training module for medical officers lacks a chapter on communication.[44] The performance of these NCD clinics and health and wellness centers (HWCs) must be evaluated.[45] We could not identify any published evaluation of the NPCDCS in common medical databases.

NNMS showed a higher proportion of participants on treatment (14.5% vs. 13.7%), and with BP under control (12.6% vs. 7.8%) as compared to NFHS-5.[5] NNMS included more participants from older age-group. The adherence and control status of older Indians has shown to be better, most probably due to their higher risk perception.[5] In the Sierra Leone study, 11% were on treatment, and 5% had controlled blood pressure. Also, the most significant loss to care (77%) was between being hypertensive and receiving a diagnosis.[35] In other international studies, the proportion of hypertensives on treatment ranged from 63% to 72.9%, which was much higher than this study which might be due to differences in the methodology and geographical variation.[37,38,42] Low adherence rates may be caused by the poor availability of medicines in the public health system and the inability of patients to buy them.[35] This might be due to the inclusion of participants from older age groups and the effect of genetic and environmental factors. 44.7% were aware of their diagnosis of NFHS-4, which is higher than this study, and 13.3% were treated, similar to this study.[9]

The study found variations in the stages of the treatment cascade among different states and union territories and across various population groups. Both in NFHS-5 and NNMS, females are more likely to reach each cascade stage than men.[5,9] However, the probability of awareness, treatment, and control did not vary by sex in NNMS.[5] This is similar to another study based on NFHS-4 for women.[9] Women utilize public health care facilities more frequently than men, as primary health care services focus more on maternal and child health in India. Women are participating better in public health-care delivery due to the presence of female community-level workers in India.

In this study, individuals from the Muslim religion, higher education status, married and living together, residents of urban areas, rich wealth index, and better housing conditions were more likely to attain all cascade stages. In NFHS 4, male sex, rural location, lower household wealth, and marital status were associated with more significant losses at each care process step. Married people had a higher likelihood of completing each care cascade step.[9] These findings are consistent with studies done in the Arab world, South Africa, and California.[30,46,47]

NFHS-5 data showed that better awareness levels were observed among individuals with higher wealth index but treatment and control did not depend on socio-economic status. In pooled data from nationally representative studies in low-income and middle-income countries (LMICs), being a woman, having a higher age, having higher education, having a good wealth index, and not being a current smoker were all significantly associated with attaining each of the four steps of the care cascade.[47] These rural-urban and socio-economic status differences have been found in the literature.[9,37,42] This might be due to the differential distribution of behavioral risk factors like tobacco use, unhealthy diet, urbanization levels, economic differences, and access to healthcare services across various socio-demographic factors. Regional differences in the international context have also been reported globally, with Latin American and Caribbean countries doing better than sub-Saharan Africa and Asia. These reviews show that improvements in the diagnosis, treatment, and control of hypertension have varied substantially across countries, with some middle-income countries now performing better than most of the high-income nations.[48]

Individuals with higher waist circumference, WHR, and BMI were more likely to have higher levels of treatment cascade if they were avoiding harmful habits like tobacco and alcohol consumption and had co-morbidities like diabetes, tuberculosis, anemia, or a history of previously screened for other co-morbidities and cancers. The presence of co-morbidities increases the likelihood of contact with health services and results

in better awareness of hypertension. However, in this study, people with high BMI and associated with other co-morbidities had a high proportion of uncontrolled blood pressure. Similar results were seen in South Africa, wherein tobacco and alcohol users and individuals with obesity were less likely to attain hypertension care cascade.[46] However, as per NFHS-4 data, being obese (BMI >30.0 kg/m^2) was associated with a higher likelihood of reaching the "treated" step, and tobacco consumption was not associated with substantial differences in the likelihood of progressing through the care cascade.[9] In NNMS data, the underweight population was also more likely to have their BP controlled.[5] However, according to the present study, having health insurance coverage and type of health care access have little role in attaining stages of the treatment cascade.

In this study, we found no specific pattern of attainment of stages of treatment cascade among states and union territories. Non-high-focus states under NHM were nicely performing in the attainment of screening, treatment, and control stages of the hypertension treatment cascade, and high-focus states under NHM were better performing in the awareness stage. Goa, Kerala, Lakshadweep, and Puducherry were performing better in screening for hypertension; the population of Bihar and Jammu and Kashmir had better awareness of their diagnosis; the population of Goa and Meghalaya was more likely on treatment for hypertension; the population of Meghalaya, Goa and Jammu and Kashmir were having their BP under control. Among high-focus states, Jammu and Kashmir were performing better in all stages of the treatment cascade, Meghalaya was good at the control stage, and Nagaland and Chhattisgarh were poorly performing states which had a high proportion of uncontrolled hypertension. Among non-high focus states, Punjab and Chandigarh had a high proportion of uncontrolled hypertension. These states need focused intervention, where most adult hypertensives did not reach the control stage. In NFHS-4, states with a large proportion of hypertensive, like Puducherry, Tamil Nadu, Sikkim, and Haryana, did not reach the control step of the care cascade ("uncontrolled hypertension").[9]

The study is based on a large and nationally representative sample from reasonable quality assurance with standard operational definitions. The study provided a detailed stratified analysis of how hypertension treatment cascade varies with different socio-demographic factors, anthropometric indicators, habits, comorbid conditions, and healthcare access. However, the study has few limitations. The study included females aged 15–49 years and males aged 15–54 years, so these results cannot be generalized to the population in India, especially to women and men aged more than 49 years and 54 years, respectively, which have higher hypertension prevalence. The hypertensives were identified on average of three BP measurements taken during one occasion, while a clinical diagnosis of hypertension requires raised BP measurements on at least two different occasions.[49] This might result in false positives of hypertensives and could result in underestimates for "aware," "on treatment," and "under control." The questions asked in the NFHS-5 questionnaire did not reveal whether diagnosed hypertensives received lifestyle advice for control of hypertension. While constructing the treatment cascade, we assumed all participants must have reached previous stages to reach the next stage; only those treated could achieve the control stage. Thus, individuals with hypertension who had blood pressure under control through lifestyle changes rather than anti-hypertensive medication were not considered to have blood pressure under control. Therefore, this analysis might underestimate the proportion of blood pressure under control.

The study concluded that the proportion of adults with hypertension in India who are aware of their diagnosis, are on treatment, and have controlled blood pressure is low. As the hypertension treatment cascade was stratified for states, this study will help policymakers select target groups and design appropriate interventions to improve hypertension care in India. While improvements are needed for all stages of the hypertension treatment cascade, this analysis showed that a higher focus is required in the current public health interventions on this population to increase the awareness and diagnosed patients to improve their likelihood of sustaining treatment of hypertension. The findings will enable the achievement of the Sustainable Development Goals (SDG) target of reducing premature mortality from NCDs by one-third by 2030 and the NCD target of a 25% reduction of raised blood pressure by 2025.

Contributors

VR, DS, SK, and NK have contributed to the study's conceptualization, data curation, formal analysis, methodology, software, supervision, validation, visualization, original draft writing, and writing review & editing. SR and SG have contributed to the study's conceptualization, supervision, validation, writing the original draft, and writing review & editing. PO has contributed to the study's conceptualization, data curation, formal analysis, methodology, and software. All authors edited and approved the final version of the manuscript.

Data sharing statement

All data are publicly available and can be accessed through The DHS Program, https://dhsprogram.com/data/.

Declaration of interests

None declared.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lansea.2023.100271.

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