Prevalence and determinants of isolated systolic and isolated diastolic hypertension in India: Insights from the national family health survey (NFHS)- 4

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ABSTRACT

Background: Isolated Systolic Hypertension (ISH) and Isolated Diastolic Hypertension (IDH) are often the ignored forms of hypertension and are determinants of future cardiac and neurological events and contribute to mortality. However, the nationally representative estimates of both these forms of hypertension remain unknown from India. Aim: To estimate the ISH and IDH from a nationally representative survey of India. Material and Methods: The present study used data from 7,23,181 people (15–54 years), recorded during the fourth round (2015–2016) of the National Family Health Survey (NFHS), India. The prevalence of ISH and IDH was calculated for state comparison, while multilevel logistic regression analysis was done to assess the correlates of both types of hypertension. Results: The prevalence of ISH and IDH was found to be 1.2% (95% CI 1.0–1.4) and 5.7% (95% CI 5.2–6.2), respectively. The prevalence of both ISH and IDH increased with age, with a more significant increase in systolic pressure towards the higher age. Northeastern states of India (Assam, Meghalaya, and Arunachal Pradesh) had the highest prevalence of both forms of hypertension. On multilevel logistic regression, male gender, increasing age groups (highest odds ratio (OR) being in 45–49 year age group), alcohol, and diabetes positively predicted both ISH and IDH. Urban residence, literacy, and tobacco were positive predictors of IDH, whereas urban residence, smoking, and literacy negatively predicted ISH. Conclusion: ISH and IDH have a significant presence among the population of India. This data provides insights to formulate strategies at the primary and primordial prevention levels.

Keywords: Isolated diastolic hypertension, isolated systolic hypertension, national family health survey, prevalence

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Received: 21-01-2022 Accepted: 08-03-2022 Revised: 25-02-2022 Published: 14-10-2022

Access this article online

Quick Response Code: Website: www.jfmpc.com DOI: 10.4103/jfmpc.jfmpc_165_22

How to cite this article: Gupta P, Sarkar PG, Verma V, Kumar A, Arora S, Kotwal A, et al. Prevalence and determinants of isolated systolic and isolated diastolic hypertension in India: Insights from the national family health survey (NFHS)- 4. J Family Med Prim Care 2022;11:5738-45.
than 8.5 million participants, the number of participants with Systolic Blood Pressure of at least 140 mm Hg has increased from 17.3% to 20.5% between 1990–2015.[3]

The most common form of hypertension in the elderly is Isolated systolic hypertension (ISH), and contributes substantially to morbidity and mortality, chiefly through cardiovascular diseases. The systolic blood pressure rises with age, and diastolic blood pressure rises till 55 years of age and starts to decrease thereafter, leading to widening of the pulse pressure. The stiffening of the central aorta leading to rapid return of the reflected pulse wave from the periphery leads to an augmentation of the systolic blood pressure.[4] ISH has a strong association with heart failure with preserved systolic function and is more common in women.

Hypertension diagnosed in middle age (30–50 years) usually has an elevated diastolic BP with a normal systolic BP- Isolated diastolic hypertension (IDH). This is more common in men and correlates with middle-aged weight gain.[5] Without treatment, this entity invariably progresses to combined systolic-diastolic hypertension. The most likely cause for this is increased systemic vascular resistance with an inappropriately normal cardiac output.

There are very few reliable estimates of the prevalence of ISH and IDH globally and from India. In a recent study from Taiwan among drug naïve adults ≥19 years, the prevalence rates of ISH and IDH were 6.51% and 1.92%, respectively.[6] According to the National Health and Nutrition Examination Survey (1999–2010), the prevalence of untreated ISH was 9.3% in the United States of America.[7] Most studies in India have been restricted to the district population, and the prevalence estimates for ISH vary between 4.3%[8] to 13.3%.[9]

The objective of this study was to determine the prevalence and determinants of ISH and IDH in the national population using the National Family Health Survey (NFHS)-4 data which was conducted in 2015–16 and covered all the states and union territories of India.

Methods

Data Source and sample size
The present study used data from 7,23,181 people (15–54 years), recorded in 2015–16, during the fourth round of the National Family Health Survey (NFHS), which is nationally representative of the Indian population. The NFHS is a multi-round large-scale survey conducted in a representative sample of households throughout India.[10] The Ministry of Health and Family Welfare (MOHFW), Government of India, designated the International Institute of Population Sciences (IIPS), Mumbai, India, as the nodal agency responsible for providing coordination and technical guidance for the NFHS. NFHS was funded by the United States Agency for International Development (USAID) with supplementary support from United Nations Children’s Fund (UNICEF). IIPS collaborated with several field organizations for survey implementation. The data is accessible on request. The link for the data is https://dhsprogram.com/data/dataset_admin/index.cfm.

Two-stage cluster random sampling, stratified by rural versus urban areas, within each district was used to cover all states. The NFHS-4 is the most recent national survey conducted in India and the only one that covers all states and union territories. However, it only included men aged 15–54 years and women aged 15–49 years.

In the NFHS-4, BP was measured three times (using the Omron HEM-8712) in the left upper arm, with at least 5 min intervals between each measurement as well as 5 min of quiet sitting before the first measurement. All BP measurements were recorded in mm of Hg.

The European Society of Cardiology (ESC) and European Society of Hypertension (ESH) 2018 guidelines were used to define hypertension (SBP ≥140 and/or DBP ≥90) and isolated systolic hypertension if SBP mmHg ≥140 with DBP <90 mm Hg.[11] Isolated diastolic hypertension was defined by the Joint National Committee (JNC) 7 criteria as systolic BP less than 140 mm Hg with a diastolic BP greater than or equal to 90 mm Hg.[12]

Data analysis and statistical methods

Study parameters
The relationship with the prevalence of ISH and IDH with some of the associated socio-economic characteristics viz., gender, age-group, place of residence, level of education, and wealth index, self-reported risk factors, viz., habits of drinking alcohol, smoking, and chewing tobacco, and having a clinical history of diabetes and any heart disease have been assessed. [Table 1] Age as reported subjectively by individuals, and grouped into eight subgroups: 15–19, 20–24, 40–44, 45–49, and 50–54. The 50 to 54 age group includes data only for the male population. The type of place of residence is classified as rural and urban. The educational qualification is classified into four classes: no-formal education, primary, secondary and higher. The economical classification was done using the wealth index and is grouped into poor, middle, and rich income classes. The prevalence of ISH and IDH in different Indian states and Union territories has been reported to visualize the pattern and geographical variations, along with gender-wise variation.

Statistical analysis
Both the events of the occurrence of ISH and IDH is considered as dichotomous variable, where if the Isolated Systolic and Diastolic blood pressure occurs, then it denotes ‘1’ and ‘0’ for otherwise, respectively. A stepwise multivariate logistic regression model has been constructed to estimate the prevalence of ISH and IDH in the Indian population aged 15 to 54 years based on their socio-economic characteristics viz., gender, age-group, place of residence, level of education, and wealth index, self-reported
risk factors, viz., habits of drinking alcohol, smoking, and chewing tobacco, and having a clinical history of diabetes or any heart disease. The results obtained from the regression analysis have been presented in terms of the odds ratios (ORs) with 95% confidence interval (CI). Statistical analysis was performed using the Statistical Analysis System (SAS) package (University Edition).

**Ethical approval**

The study was ethically approved by the Institute’s Ethics Committee, Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh (PGI/IEC/2021/001139).

**Results**

**Demographics**

More than 50% of the total of 7,23,181 people surveyed belonged to the 15–29 years age group. A little over 70 percent of the total surveyed population lived in a rural household, and 26.1% never had access to any form of education. A total of 39.2% of the population belonged to the poorest category according to the wealth index, 6.4% had a history of any form of alcohol intake, and 15.89% were smokers. According to the NFHS IV survey, the prevalence of ISH and IDH was found to be 1.2% (95% CI 1.0–1.4) and 5.7% (95% CI 5.2–6.2), respectively. The prevalence of both ISH and IDH increased with age, with a more significant increase in systolic pressures towards the higher age.

**Prevalence of isolated systolic and diastolic hypertension at national and state level**

Significant heterogeneity is present in the state-wise distribution of isolated forms of hypertension [Table 2, Figure 1]. The northeastern states of Meghalaya (2.3%; 95% CI: 2–2.6) and Assam (2.2%; 95% CI: 1.9–2.5) had the highest prevalence of ISH, whereas Andhra Pradesh and Maharashtra had the lowest prevalence of ISH at (0.7%; 95% CI: 0.5–0.9). The highest prevalence of IDH was found in Arunachal Pradesh (9.5%; 95% CI: 8.9–10.8) followed by Assam (8.6%; 95% CI: 8.0–9.1) and Sikkim (8.6%; 95% CI: 8.0–9.1), and lowest in Bihar and Kerala (3.9%; 95% CI: 3.5–4.2). A concordant relationship was seen between ISH and IDH prevalence; states which had a higher prevalence of ISH also displayed a higher prevalence of IDH.

States with the highest percentage of females with ISH were Meghalaya (2.3%) and Assam (2%), and with IDH were Arunachal

| Table 1: Distribution of ISH and IDH with Socio-demographic characteristics and risk factors |
|---------------------------------|----------------|-----------------|-----------------|----------------|
| Variables                        | Total (n=723181) | Isolated Systolic Hypertension (n=8710, P=1.2%) | Isolated Diastolic Hypertension (n=41314, P=5.7%) | P               |
|---------------------------------|----------------|----------------|----------------|----------------|
| Gender                          |                |                |                | <0.0001         |
| Male                            | 100709 (13.9)  | 2092 (24.0)    | 8108 (19.6)    |                |
| Female                          | 622472 (86.07)| 6618 (76.0)    | 33206 (80.4)   |                |
| Age (years)                     |                |                |                | <0.0001         |
| 15-19                           | 136307 (18.8)  | 703 (8.1)      | 2903 (7.0)     |                |
| 20-24                           | 128229 (17.7)  | 824 (9.5)      | 4196 (10.2)    |                |
| 25-29                           | 117901 (16.3)  | 846 (9.7)      | 5709 (13.8)    |                |
| 30-34                           | 98689 (13.6)   | 900 (10.4)     | 6772 (16.4)    |                |
| 35-39                           | 90799 (12.5)   | 1244 (14.3)    | 7828 (19.0)    |                |
| 40-44                           | 75280 (10.4)   | 1611 (18.5)    | 6885 (16.7)    |                |
| 45-49                           | 68838 (9.5)    | 2279 (26.2)    | 6223 (15.1)    |                |
| 50-54                           | 7138 (0.9)     | 294 (3.4)      | 798 (1.9)      |                |
| Place of residence              |                |                |                | <0.0001         |
| Urban                           | 206918 (28.6)  | 2107 (24.2)    | 12891 (31.2)   |                |
| Rural                           | 516263 (71.4)  | 6603 (75.8)    | 28423 (68.8)   |                |
| Education Level                 |                |                |                | <0.0001         |
| Higher                          | 84970 (11.7)   | 718 (8.2)      | 4587 (11.1)    |                |
| Secondary                       | 357565 (49.4)  | 3474 (39.9)    | 18447 (44.7)   |                |
| Primary                         | 91217 (12.6)   | 1214 (13.9)    | 5963 (14.4)    |                |
| No education                    | 189429 (26.1)  | 3304 (37.9)    | 12317 (29.8)   |                |
| Wealth index                    |                |                |                | <0.0001         |
| Poorest                         | 284194 (39.2)  | 3437 (39.5)    | 15250 (36.9)   |                |
| Middle                          | 148945 (20.5)  | 1729 (19.9)    | 8557 (20.7)    |                |
| Richest                         | 290042 (40.1)  | 3544 (40.7)    | 17507 (42.4)   |                |
| Drink alcohol                   | 46787 (6.4)    | 1046 (12.0)    | 4648 (11.3)    | <0.0001         |
| Smoker                          | 114981 (15.8)  | 1993 (22.9)    | 8994 (21.8)    | <0.0001         |
| Chewing tobacco                 | 8582 (1.1)     | 137 (1.6)      | 715 (1.7)      | <0.0001         |
| Currently has diabetes          | 8579 (1.1)     | 226 (2.6)      | 853 (2.1)      | <0.0001         |
| Currently has heart disease     | 9197 (1.2)     | 171 (2.0)      | 669 (1.6)      | <0.0001         |
The urban households were associated with lower odds of having ISH (OR 0.81, CI 0.77–0.86, P < 0.0001) but higher odds of developing IDH (OR 1.12, CI: 1.10–1.15, P < 0.0001).

Educational qualification had an inverse relationship with ISH and IDH with higher education status predicting lower odds of developing ISH (OR 0.75; CI 0.69–0.82, P < 0.0001), and primary education status was associated with higher odds of IDH (OR 1.10; CI 1.06–1.14, P < 0.0001). Alcohol and diabetes were found to be positively associated with the development of these two forms of hypertension, whereas tobacco use had an OR of 1.11 for IDH.

### Discussion

To the best of our knowledge, this is the first study that determines the prevalence of ISH and IDH in India stratified by the geographical region, gender, and socio-demographic determinants, based on the NFHS-4 data collected in the year 2015–16.

The overall prevalence of ISH (1.2%) is very low in contrast to other studies conducted in India and abroad. The prevalence of ISH has been estimated at 4.3% in Lucknow, 25% in the Davengere district of Karnataka, and 15.3% in the National capital of Delhi. India in an elderly population (> 60 years). Similar estimates have been reported from the United States, with a prevalence of 9.4% in adults aged > 18 years and 45.5% among older adults. The low prevalence of ISH in our study may be due to the inclusion of younger age groups (15–54) in the analysis, and ISH is predominantly a disease of the older population. However, the prevalence of ISH increased with age in our study, with the maximum proportion falling in the 45–49 year age group (26.2%) which is similar to studies reported above.

The prevalence of IDH in our study was found to be high at 5.7% when compared to other studies. Mittal et al. reported a prevalence of 4% in a semi-rural population of South India. Another community-based survey conducted in Uttar Pradesh and Mizoram showed a prevalence of IDH at 4.5% and 3.43% respectively. A Chinese study with 23,10,184 participants in the PEACE (Patient-Centered Evaluative Assessment of Cardiac Events) Million Persons Project showed a prevalence of IDH as 3.2%. It is evident that diastolic pressure rises till 55 years of age and falls thereafter. The same has been found in the present study, with a steady increase in the prevalence of IDH till 39 years and decreasing thereafter.

In our study, greater proportions of both ISH and IDH were found in people living in rural areas, achieved secondary education level, and belonged to the richest quintile of the wealth index. In a study conducted in China, ISH prevalence was higher among rural women, similar to our study.

### Determinants of ISH and IDH

Age was found to be significantly associated with ISH, with the prevalence of ISH steadily increasing with age group until 49 years of age. A similar trend was seen with IDH with a peak at the age of 35–39 followed by a decrease. Stepwise Logistic Regression has been adopted for the selection of concomitant variables to remove non-significant variables from the model. Higher age was found to be associated with a higher odds ratio (OR) for the development of ISH and IDH.

**Table 2: State-wise distribution of ISH and IDH**

| States/Territories | Total | Isolated Systolic Hypertension (%) | Isolated Diastolic Hypertension (%) |
|--------------------|-------|-----------------------------------|-----------------------------------|
|                    |       | (95%CI)                           | (95%CI)                           |
| A & N Islands      | 9916  | 0.8 0.7‑1.0                      | 7.0 6.5‑7.5                      |
| Andhra Pr.         | 10042 | 0.5 0.5‑0.9                      | 6.4 6.0‑6.9                      |
| Arunachal Pr.      | 14204 | 2.0 1.7‑2.3                      | 9.5 8.9‑10.1                     |
| Assam              | 29034 | 2.2 1.9‑2.5                      | 8.6 8.0‑9.1                      |
| Bihar              | 47816 | 1.0 0.8‑1.2                      | 3.9 3.5‑4.2                      |
| Chandigarh         | 698   | 0.7 0.7‑1.0                      | 5.6 5.1‑6.0                      |
| Chhattisgarh       | 27531 | 1.3 1.1‑1.6                      | 5.4 5.0‑5.9                      |
| D & N Haveli       | 937   | 0.8 0.6‑0.9                      | 5.9 5.3‑6.2                      |
| Daman & Diu        | 1651  | 1.3 1.0‑1.5                      | 4.8 4.4‑5.2                      |
| Delhi              | 4722  | 1.1 0.9‑1.3                      | 4.4 4.0‑4.8                      |
| Goa                | 2369  | 1.2 1.0‑1.4                      | 6.2 5.7‑6.7                      |
| Gujarat            | 26651 | 1.1 0.9‑1.3                      | 6.4 5.9‑6.9                      |
| Haryana            | 19817 | 1.7 1.5‑2.0                      | 6.1 5.7‑6.6                      |
| Himachal Pr.       | 10716 | 1.3 1.1‑1.5                      | 7.9 7.3‑8.4                      |
| J &K               | 24967 | 1.8 1.5‑2.0                      | 5.2 4.8‑5.7                      |
| Jharkhand          | 29349 | 1.0 0.8‑1.2                      | 5.4 4.9‑5.8                      |
| Karnataka          | 27448 | 1.3 1.1‑1.5                      | 6.0 5.5‑6.5                      |
| Kerala             | 12127 | 1.4 1.2‑1.6                      | 3.9 3.5‑4.3                      |
| Lakshadweep        | 1143  | 1.8 1.5‑2.0                      | 4.8 4.4‑5.2                      |
| Madhya Pr.         | 68192 | 1.0 0.8‑1.2                      | 5.4 5.0‑5.8                      |
| Maharashtra        | 30996 | 0.7 0.5‑0.9                      | 6.8 6.3‑7.3                      |
| Manipur            | 13979 | 0.9 0.7‑1.1                      | 7.4 6.9‑7.9                      |
| Meghalaya          | 9187  | 2.3 2.0‑2.6                      | 4.2 3.8‑4.6                      |
| Mizoram            | 12078 | 0.8 0.6‑1.0                      | 6.2 5.7‑6.6                      |
| Nagaland           | 10935 | 1.3 1.1‑1.6                      | 8.4 7.8‑8.9                      |
| Orissa             | 34050 | 1.2 1.0‑1.4                      | 5.1 4.7‑5.6                      |
| Pondicherry        | 3636  | 0.9 0.8‑1.1                      | 6.4 5.9‑6.8                      |
| Punjab             | 19906 | 2.0 1.7‑2.2                      | 7.2 6.7‑7.7                      |
| Rajasthan           | 44765 | 1.1 0.9‑1.3                      | 4.5 4.1‑4.9                      |
| Sikkim             | 5206  | 1.6 1.3‑1.8                      | 8.6 8.0‑9.1                      |
| Tamil Nadu         | 25829 | 0.9 0.7‑1.1                      | 6.0 5.5‑6.5                      |
| Tripura            | 5056  | 1.1 0.9‑1.3                      | 7.1 6.6‑7.6                      |
| Uttar Pr.          | 102265| 1.0 0.8‑1.2                      | 4.7 4.2‑5.1                      |
| Uttaranchal        | 17551 | 1.0 0.8‑1.2                      | 6.1 5.6‑6.6                      |
| West Bengal        | 18412 | 1.6 1.3‑1.8                      | 5.1 4.7‑5.5                      |
| India              | 723181| 1.2 1.0‑1.4                      | 5.7 5.2‑6.2                      |

The prevalence of ISH in our study stratified by the state/Territory shows that the highest percentage of males with ISH were seen in Lakshadweep (4.9%), followed by Haryana (4.3%), and with IDH were Sikkim (11.9%) and Assam and Pradesh (9.2%) respectively. A Chinese study with 23,10,184 participants in the PEACE (Patient-Centered Evaluative Assessment of Cardiac Events) Million Persons Project showed a prevalence of IDH as 3.2%. It is evident that diastolic pressure rises till 55 years of age and falls thereafter. The same has been found in the present study, with a steady increase in the prevalence of IDH till 39 years and decreasing thereafter.

In our study, greater proportions of both ISH and IDH were found in people living in rural areas, achieved secondary education level, and belonged to the richest quintile of the wealth index. In a study conducted in China, ISH prevalence was higher among rural women, similar to our study.
On multilevel logistic regression, male, increasing age groups (highest OR being in 45–49 year age group), alcohol and diabetes positively predicted both ISH and IDH. Urban residence, literacy, and tobacco were positive predictors of IDH, whereas urban residence, smoking, and literacy negatively predicted ISH. The findings are similar to a study conducted in the rural population of China, where ISH was positively correlated with age, alcohol, and obesity.\[20\]

The association of ISH with alcohol in our study corroborates with the literature. In the Davengere district of India, a higher prevalence of ISH was seen in current alcoholics and ex-smokers.\[13\] Similarly, a significant association of ISH was seen with age, alcohol, and smoking, and a non-significant association was seen with urban residence and socio-economic status in a district of Lucknow.\[8\] In a study conducted in China, smoking was found to be the strongest modifiable predictor of ISH.\[28\]

However, it was in contrast to our study wherein smoking was negatively associated with ISH.

The prevalence of ISH and IDH was higher in males (24 and 19.6) as compared with females (1.06 and 5.33, respectively). Being male was significantly associated with an increased risk for IDH has also been reported in other studies.\[15‑18\] Regarding ISH, other studies have reported no association with male gender or females having a higher chance of ISH.\[20\]

One of the important points to be noted is that females were overrepresented in our study, possibly because it was a household survey, and it is likely that the survey team encountered the non-working females at the time of the survey.

In our study, the northeastern states of Assam and Meghalaya had the highest prevalence of ISH, and Sikkim and Arunachal Pradesh had the highest prevalence of IDH. States of

Table 3: Gender wise distribution of ISH and IDH

| States or Territories                     | Total | Male | Female | Male | Female | Male | Female |
|------------------------------------------|-------|------|--------|------|--------|------|--------|
| Andaman and Nicobar Islands              |       | 1342 | 8574   | 1.71 | 0.70   | 11.03| 6.32   |
| Andhra Pradesh                           |       | 1304 | 8738   | 1.61 | 0.56   | 10.51| 5.84   |
| Arunachal Pradesh                        |       | 1828 | 12376  | 3.61 | 1.78   | 11.54| 9.18   |
| Assam                                    |       | 3719 | 25315  | 3.79 | 2.01   | 10.08| 8.34   |
| Bihar                                    |       | 5472 | 42344  | 1.35 | 0.94   | 5.65 | 3.64   |
| Chandigarh                                |       | 103  | 595    | 1.94 | 0.67   | 8.74 | 5.04   |
| Chhattisgarh                              |       | 3647 | 23884  | 2.17 | 1.21   | 7.57 | 5.11   |
| Dadra and Nagar Haveli                    |       | 195  | 742    | 1.03 | 0.67   | 9.23 | 4.85   |
| Daman and Diu                             |       | 383  | 1268   | 1.83 | 1.10   | 3.66 | 5.13   |
| Delhi                                    |       | 468  | 4254   | 2.56 | 0.94   | 5.34 | 4.33   |
| Goa                                      |       | 791  | 1578   | 1.64 | 0.95   | 9.23 | 4.69   |
| Gujarat                                  |       | 5513 | 21138  | 1.71 | 0.89   | 8.02 | 5.97   |
| Haryana                                  |       | 2872 | 16945  | 4.32 | 1.29   | 11.47| 6.98   |
| Himachal Pradesh                          |       | 2102 | 8614   | 2.85 | 0.94   | 6.12 | 5.01   |
| Jammu and Kashmir                         |       | 5309 | 19658  | 2.94 | 1.44   | 7.10 | 5.14   |
| Jharkhand                                 |       | 3592 | 25757  | 1.50 | 0.90   | 9.30 | 5.50   |
| Karnataka                                 |       | 3699 | 23749  | 2.24 | 1.14   | 4.90 | 3.69   |
| Kerala                                    |       | 1919 | 10208  | 2.24 | 1.23   | 3.09 | 5.10   |
| Madhya Pradesh                            |       | 9690 | 58502  | 1.24 | 0.91   | 7.37 | 5.07   |
| Maharashtra                               |       | 4296 | 26700  | 1.37 | 0.61   | 10.68| 6.19   |
| Manipur                                   |       | 1711 | 12268  | 2.05 | 0.72   | 10.70| 6.95   |
| Meghalaya                                 |       | 1120 | 8067   | 2.23 | 2.32   | 6.25 | 3.87   |
| Mizoram                                   |       | 1552 | 10526  | 1.87 | 0.62   | 9.73 | 5.63   |
| Nagaland                                  |       | 1341 | 9594   | 3.73 | 0.99   | 10.59| 8.06   |
| Orissa                                    |       | 4152 | 29898  | 1.71 | 1.13   | 7.44 | 4.81   |
| Pondicherry                               |       | 518  | 3118   | 1.74 | 0.80   | 10.04| 5.74   |
| Punjab                                    |       | 2914 | 16092  | 3.53 | 1.70   | 10.50| 6.66   |
| Rajasthan                                 |       | 5918 | 38847  | 2.31 | 0.88   | 6.91 | 4.17   |
| Sikkim                                    |       | 734  | 4472   | 3.41 | 1.27   | 11.99| 8.01   |
| Tamil Nadu                                |       | 4192 | 21637  | 1.60 | 0.73   | 10.09| 5.22   |
| Tripura                                   |       | 798  | 4258   | 1.75 | 0.99   | 7.14 | 7.07   |
| Uttar Pradesh                             |       | 12975| 89290  | 1.48 | 0.95   | 6.25 | 4.43   |
| Uttaranchal                               |       | 1982 | 15569  | 1.87 | 0.91   | 10.85| 5.49   |
| West Bengal                               |       | 2396 | 16016  | 2.38 | 1.47   | 6.64 | 4.86   |
| India                                     |       | 100709| 622472 | 2.07 | 1.06   | 8.05 | 5.33   |
Andhra Pradesh and Maharashtra had the lowest prevalence of ISH, and states of Bihar and Kerala had the lowest prevalence of IDH. To the best of our knowledge, this is the first study to capture all the states and union territories of the country.
Some studies have reported the state-wise prevalence of ISH and IDH. In the ICMR-INDIAB study[21] published in 2015, wherein individuals >20 years of age were surveyed in three states (Tamil Nadu, Maharashtra, and Jharkhand) and one union territory of Chandigarh, the prevalence of ISH was 12.1% in Tamil Nadu and Jharkhand, 10.5% in Maharashtra and 7.8% in Chandigarh. The prevalence of IDH was 4.6%, 4%, 3.8%, and 2.5% in Maharashtra, Jharkhand, Chandigarh, and Tamil Nadu, respectively. In another study from Mizoram, the prevalence of ISH and IDH was 2.05% and 3.43%, respectively.[27]

The main strengths of the study are that it is nationally representative data with a huge sample size providing robust estimates of ISH and IDH prevalence. The data fills a critical gap in knowledge about the burden of ISH and IDH in a relatively younger population (15–54 years), which was unknown so far for India. Both forms of hypertension are determinants of future cardiac and neurological events, and active treatment of patients with ISH can reduce all-cause mortality by 13%, cardiovascular mortality by 18%, all cardiovascular events by 26%, stroke by 30%, and coronary events by 23%. So any intervention at the primordial, primary, or secondary level can have a huge impact on outcome improvement. ISH and IDH have been conspicuous by their absence in any form of national programs in India, and there is a strong unmet need to include them in future studies and national policies. However, we acknowledge a few limitations. Firstly, women have been over-represented, and this may have skewed the data and increased the overall prevalence of IDH because it is more common in women. Secondly, the age group has been restricted to 54 years, and ISH is predominantly a disease of the elderly, so it may have led to an underestimation of the actual burden of disease. Thirdly, since this is a survey-based study done in an uncontrolled environment, it may have some element of measurement errors.

**Conclusion**

The prevalence of ISH and IDH in India was found to be 1.2% and 5.7%, respectively. Increasing age, male, rural household, alcohol intake, and diabetes emerged as significant predictors for ISH. Along with these, other significant determinants of IDH are literacy and tobacco use. This information can help formulate and modify public health policies and programs targeting non-communicable diseases and can go a long way towards achieving sustainable development goals.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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