Household Level Clustering of Hypertension and Diabetes Across Districts of India: Evidence From A Nationally Representative Household Survey

Introduction

Non-communicable diseases (NCDs) in India pose a formidable public health challenge both in terms of high and increasing prevalence and low level of awareness, diagnosis and adequate treatment.[1–3] As per recent estimates, approximately 220 million people are suffering from hypertension and 77 million people are suffering from diabetes in India.[4–6] However only half of the people with hypertension and only 36% of the people with diabetes are under medication.[7,8] In addition, there are wide socioeconomic and geographic variations in distribution of these diseases in India.[9,10]

The NCDs are often agglomerated within families due to shared genetic factors, common environmental exposures and social transmission of lifestyle, food patterns, and high-risk behaviours associated with NCDs.[11,12] Familial agglomeration of NCDs is well documented, mostly in studies from western countries.[13–18] Though limited, existing evidence from India also suggests familial clustering of risk factors for NCDs/hypertension/diabetes.[19–24] Cognizance of household level clustering is essential for complete understanding of the epidemiology of hypertension and diabetes in India. Along with providing valuable insights about disproportionate disease distribution across households, examination of clustering will help in better understanding of the complex interactions between genetic predispositions, environmental factors, and social influences that may result in disease agglomeration within households. This understanding will be immensely helpful to potentially strategize interventions for prevention, diagnosis, and management of hypertension and diabetes to be targeted at household level in addition to the interventions targeted at the individual level.

India is most populous and a diverse country with huge geo-climatic, cultural, dietary, sociodemographic, and economic variations. In terms of burden of hypertension and diabetes, different states in India are at different levels.[1,3,8] States in India are also not homogenous units and different regions within a state vary considerably in terms of climate, urbanization, and economic activities.[25–28] Therefore, for better understanding of distribution of these diseases, one must look below the state level. Districts in India are administrative units and the health-related planning and execution is done at district level. Examination of household level

clustering of hypertension and diabetes at district level is therefore essential for planning and implementation of interventions for diagnosis, prevention, and management of these diseases efficiently in integrated manner as per priorities of the districts.

There are limited studies examining familial clustering of hypertension or diabetes in India. The existing studies are majorly hospital based and limited in geographical areas or population groups.[29–34] Only a few studies have attempted to examine familial agglomeration of chronic conditions and hypertension using representative samples in India. However, the focus of these studies is limited to explain concordance of hypertension within married couples.[19–22] Present study delves into the phenomenon of clustering of hypertension and diabetes within households to examine the distribution and determinants of clustering across districts in India.

Existing literature supports the role of neighbourhood factors like health relevant environments, behavioural practices, social factors, and health policies in explaining health or disease status of an individual independent of the individual level characteristics.[35,36] Households share common exposure to various neighbourhood factors along with common environment exposures which are modulated at different levels of population settlements and administration units like community, district and state. Examination of clustering of these diseases at household level using hierarchical data by applying multilevel modelling can provide insights into the role played by such factors applicable at different levels like community, district, and state. The role of neighbourhood factors and variations at different population levels in the context of NCDs has not received much attention in India. Very few studies from India have examined such variations. However, they have focused on overall prevalence of NCDs, risk factors for NCDs, and limited to particular states in India.[24,37,38] Given this important gap in the literature, we examined the variation in clustering of hypertension and diabetes within households across India attributable to various factors at community, district, and state level.

Methods

Data Source

We used data from the fifth round of the National Family Health Survey (NFHS-5) conducted in India during 2019-21. NFHS-5, also known as India Demographic and Health Survey, is a nationally representative household survey conducted across 28 states and 8 union territories of India. NFHS-5 used a two-stage stratified sampling design in both urban and rural areas. The detailed information on sampling design can be found elsewhere.[39] The total number of households interviewed in NFHS-5 were 636699, with a response rate of 98%. Of these, 619839 households were considered for analysis for clustering of hypertension where blood pressure measurement was completed for at-least one member of the household.

Information about consumption of different food items was collected by interviewing women age 15-49 years and weight and height measurements were taken after completion of interview. Therefore, analysis involving consumption of food items and body mass index was restricted to 500267 households where at-least one woman's interview was completed along with measurement of blood pressure of at-least one member of the household. Similarly clustering for diabetes was examined in 615125 households where random blood glucose testing was completed for at-least one member of the household and further analysis involving consumption of food items and BMI was restricted to 497949 households where any eligible woman's interview was completed along with RBG measurement.

Measurement

In NFHS-5, blood pressure (BP) and random blood glucose level of eligible men and women age 15 years or above in the surveyed households were measured using standard equipment and following standardized protocol. The detailed protocol for measurement of anthropometry, BP and blood glucose can be found elsewhere.[40] BP was measured after completion of survey questionnaire from eligible respondents and obtaining informed consent. BP was measured in a single home visit using Omron HEM 812 automatic digital BP monitor manufactured by Omron Healthcare Vietnam Co. Ltd, Vietnam. A total of three measurements were taken, preferably on the left arm in a sitting position, with a five-minute gap between two consecutive measurements. The average systolic and diastolic blood pressure from second and third measurements were considered as the final measurement for analysis. Random blood glucose was measured using Accu-Chek Performa glucometer manufactured by Roche Diabetes Care, Inc. USA by drawing capillary blood after obtaining informed consent. Along

with measurement, all the eligible respondents who consented for blood pressure measurement were asked questions about diagnosis prior to survey- *were you told on two or more occasions by a doctor, nurse or auxiliary nurse midwife (ANM) that you had hypertension or high blood pressure?* and *to lower your blood pressure, are you now taking a prescribed medicine?* Similarly, all the eligible respondents who consented for blood glucose measurement were asked questions about diagnosis prior to survey- *were you told on two or more occasions by a doctor, nurse or auxiliary nurse midwife (ANM) that your blood glucose level was high?* and *to lower your blood glucose level, are you now taking a prescribed medicine?*

Among the respondents, hypertensives were identified as those having Systolic Blood Pressure (SBP) ≥ 140 mmHg or Diastolic Blood Pressure (DBP) ≥ 90 mmHg or taking any medication to lower blood pressure at the time of survey. Likewise, diabetics were identified as those having a random blood glucose level greater than 140 mg/dL or taking any medicines for diabetes.

The details of weight and height measurement can be found in S1. The detailed protocol of biomarkers and biomarker questionnaire can be found elsewhere.[40,41]

Analytical Procedure

Household level clustering for a disease occurs when a household has two or more members identified with that particular disease. So, household level clustering for hypertension occurs when two or more members of a household are identified with hypertension. Similarly, household level clustering for diabetes occurs when two or more members of a household are identified with diabetes. We analysed the clustering for hypertension and diabetes separately.

The variations in clustering at household level were assessed by various characteristics of household, head of the household, and PSU. The household characteristics included in the analysis are number of members of the household drinking alcohol, number of members consuming tobacco in any form, share of members age 15 years and above in the household, household's economic status (wealth quintiles) and presence of any overweight/obese woman in the household. When it comes to the characteristics of the household head, caste, religion, and education of the head of household were included in the analysis. The PSU level characteristics included for analysing clustering were place of residence of the household and

percentage of *pucca* households within the PSU. The percentage of *pucca* households in the PSU was taken as a proxy indicator of economic status of the immediate surroundings.

In the absence of information about overweight/obese status of all household members in NFHS-5, we included presence of any overweight/obese woman in the household as a proxy indicator for obesity status of the entire household. Wealth index is considered a good proxy indicator of the economic status of the households in NFHS where income or expenditure data is not collected. The wealth index was constructed by principal component analysis using data on household's ownership of selected assets, access to utilities and infrastructure, and housing characteristics of households surveyed in NFHS-5.[39]

In NFHS-5 men were not interviewed in all of the communities (PSUs). In the absence of information from men interview in all PSUs, the information of different types of food consumption collected by interviewing women age 15-49 years in all households can be considered a good proxy indicator for food consumption by entire household as food preparation is usually same for the entire household. Also, in the households where both men and women were interviewed, the consumption of almost all food items considered in our analysis was higher among men than women.[39,42] The food items included in the analysis are daily or weekly consumption of milk or milk products, chicken or meat, fried food, and aerated drinks.

We estimated four-level random intercept logistic regressions to examine the association of household-, community-, district- and state- level variables with household clustering of hypertension and diabetes. We also estimated the intraclass correlation coefficient (ICC) at community, district, and state levels.

A four-level random intercept logistic regression model can be mathematically represented as

$$\log\left(\frac{\pi_{ijk}}{1-\pi_{ijkl}}\right) = Y_{ijkl} = a = \beta X_{ijkl} + \gamma Z_{jkl} + \delta W_{kl} + \phi U_l + r_{0l} + s_{0kl} + d_{0jkl} + e_{0ijkl}$$

where Y_{ijkl} is the household with clustering of selected NCD for household *i* in the community *j* in district *k* in state *l*. a is constant, $X_{ijkl}, Z_{jkl}, W_{kl}, and\ U_l$ are the vectors of the

variables. β , γ , δ , and ϕ are the regression coefficients. $r_{0l}, s_{0kl}, d_{0jkl}, and\ e_{0ijkl}$ are the residuals at household, community, district, and state levels respectively.

$$ICC = \frac{VAR_n}{\{\sum_{n=2}^{N} VAR_n + (\frac{\pi^2}{3})\}}$$

Where ICC is the intraclass correlation coefficient and VAR_n is the variance at the nth level of regression.

Four-level random intercept logistic regressions were estimated on two sets of samples. First set of samples consisted of households where blood pressure and blood glucose were measured in the households. As food consumption and BMI were available only for women age 15-49, we estimated our models on a second set of samples. The second set of samples is a sub-set of the first set and consisted of households where women age 15-49 were interviewed along with blood pressure and blood glucose measurements. The variables added in the second set of analyses were daily or weekly consumption of milk or milk products, chicken or meat, fried food, and aerated drinks and presence of any overweight/obese woman in the household. Since men were not interviewed in all of the communities (PSUs), information from men's interview or anthropometry measurements were not included in the regression models.

The analysis was done using MLwiN, STATA 16 and ArcGIS.[43–45]

Ethical consideration

Our study uses secondary data from NFHS-5 which is available for public use. Data can be accessed from DHS data repository (https://dhsprogram.com/data/available-datasets.cfm). The NFHS-5 dataset do not have any information that could identify respondents' identities, households, or sample communities. So ethical approval is not required for our study.

Results

Table 1 shows the characteristics of the surveyed households. The characteristics of the households analysed for clustering of hypertension were similar to those analysed for clustering of diabetes. No member age 15 years and above consumed alcohol in 73.1% of households, only one member consumed alcohol in 22.5% households, two members consumed alcohol in 3.5% of households, whereas in only one percent households three or more members consumed

alcohol. No member consumed tobacco in almost half (46.6%) of the households, only one member used tobacco in 36.6% of households, two members used tobacco in 12.3% of households, and three or more members consumed tobacco in 4.5% of households. The mean percentage share of members age 15 years and above in the households was 77.9%. About four-tenths (41.7%) of household heads belonged to other backward classes (OBC), 21.8% belonged to scheduled castes (SC), 9.7% belonged to scheduled tribes (ST), and 26.8% belonged to *other* castes. Majority of the household heads belonged to Hindu religion (82.2%), followed by Muslim (12.2%), Christian (2.8%), and Sikh (1.5%). Forty-two percent household heads had completed secondary schooling and 10.5% had completed higher than secondary schooling. About a-fifth (18.8%) of the household heads completed primary schooling and 28.7% did not receive any schooling. About two-thirds (67.9%) of the households resided in rural areas. On an average, proportion of *pucca* houses in the community was 59.7%. Based upon women's interview, milk or milk products were consumed on daily or weekly basis by 75.2% women, fish and meat by 40.0% and 40.1% respectively, fried food by 47.3%, and aerated drinks by 18%. At least one woman was either overweight or obese in 30.4% of households where women were interviewed and BP or RBG were measured.

Table 2 shows the percent distribution of households (HHs) with number of members identified with hypertension and diabetes along with the proportion of total cases nested within them. Among 14.9% households two or more members age 15 years or above were identified with hypertension. Only two members age 15 years or above were identified with hypertension in 11.6% of households, three members in 2.3% households and four, five, and six or more members were identified in less than one percent of households each. About half of the total case burden of hypertension in India was nested within these 14.9% of households with clustering. Only one member was identified with hypertension in 32.4% of households, harbouring half of the case burden of hypertension. In 53.2% of the households, not a single member was identified with hypertension.

In one-twelfth of households (8.2%) two or more members age 15 years or above were identified with diabetes, which contributed to 39.3% of total case burden of diabetes in India. Only two members age 15 and above were identified with diabetes in around 7% of the households, three members in around 1% of the households whereas four, five, and six or more members were identified with diabetes in less than 1% of the households each. In 26.6% of

households only one member was identified with diabetes, bearing 60.8% of total case load of diabetes whereas, in 68.1% of households no member was identified with diabetes.

Table 3 shows the prevalence of clustering of hypertension and diabetes by selected household characteristics. The prevalence of clustering of hypertension was higher among urban households (17.1% than rural households (13.9%). Among the caste groups, the prevalence of clustering of hypertension was highest among households headed by other castes (17.1%). The prevalence of clustering of hypertension was lowest among households headed by ST (12.9%). Among the religious groups, Sikhs had the highest prevalence of clustering of hypertension (29.4%), followed by Christians (17.3%), Hindus (14.8%), and Muslims (13.6%). Among lowest wealth quintile households, clustering of hypertension was observed in around 9% households, which increased to 22% in highest wealth quintile households. The prevalence of clustering increased with the number of members per household consuming alcohol or tobacco. Clustering of hypertension increased from 15% among households with only one member consumed alcohol to 26% where three or more members consumed alcohol. The prevalence of clustering for hypertension increased from 13% among households with only one member using tobacco to 23% among households with three or more members using tobacco. Clustering for hypertension was more in households that consumed milk or milk products (15.4%), fried food (15.2%), and aerated drinks (15.9%) daily or weekly.

The prevalence of clustering of diabetes was higher among urban households (10.1%) than rural households (7.3%). The caste-based gradient was steeper in case of diabetes where prevalence of clustering for diabetes was almost double (10.2%) among households where household heads belonged to other castes than the households where heads belonged to ST (5.3%). The prevalence of clustering of diabetes varied less by religious groups compared to the prevalence of clustering of hypertension. The prevalence of clustering of diabetes was highest among Christians (10.7%) and lowest among households headed by members who are neither Hindu, Muslim, Sikh or Christian (6.0%). The prevalence of clustering of diabetes increased with increase in the household wealth quintile; the prevalence of clustering of diabetes almost tripled from around 5% among households in lowest wealth quintile to 13% in highest wealth quintile. The clustering of diabetes among households with only one-member consuming alcohol and three or more members consuming alcohol was 8% and 12%, respectively. Likewise, the prevalence of clustering for diabetes increased from 7% among households with only one member using tobacco to 13% among households with three or more

members using tobacco. Higher prevalence of diabetes clustering was seen in households consuming milk or milk products (8.7%), fish (9.7%), meat or chicken (9.2%), fried food (8.9%), and aerated drinks (9.5%) on a daily or weekly basis.

Higher prevalence of clustering of hypertension (20.5%) and diabetes (11.9%) was seen in households where any woman age 15-49 was overweight or obese.

Figure 1 and **Figure 2** show the spatial distribution of households with clustering of hypertension and diabetes across the districts in India, respectively (The district wise prevalence can be seen in Supplementary Material: **Table S1**). The proportion of households with clustering for hypertension ranged from around 4.0% in Kaushambi (Uttar Pradesh) to 37.3% in Amritsar (Punjab). In about a-third of households in Hoshiarpur, Shahid Bhagat Singh Nagar, Bathinda (All Punjab), West Delhi district (NCT Delhi), Kurukshetra (Haryana), Mahe (Puducherry), and Gurdaspur (Punjab) clustering for hypertension was identified. In particular, many districts in Punjab, Haryana, Kerala, Southern Karnataka, Western Maharashtra, Chhattisgarh, Jharkhand, Sikkim, and Arunachal Pradesh showed higher prevalence (>20%) of clustering of hypertension within households. The clustering of diabetes ranged from about one percent in Kra Daadi (Arunachal Pradesh) to 25% in Mahe (Puducherry). Clustering for diabetes was observed in about one-sixth of the households in Pathanamthitta, Kollam, Kottayam, Thrissur (All Kerala), Morbi (Gujarat), Ernakulam, Alappuzha, Palakkad (All Kerala), and Ahmedabad (Gujarat). The districts with higher prevalence (>10%) of clustering within households were observed in entire Kerala and Tamil Nadu, Saurashtra, Coastal Karnataka, Andhra Pradesh, Coastal regions of Odisha, and West Bengal.

The district-wise spatial distribution of percentage of households with any member consuming alcohol, using tobacco, daily or at-least weekly consumption of chicken or meat, fried food, fish, curd or milk, aerated drinks, and percentage of households with at-least one woman obese or overweight are shown in Supplementary Material: **Figure A1**. The prevalence of alcohol consumption by any member of the household is high in almost all districts of Telangana, Arunachal Pradesh, Sikkim, Himachal Pradesh, Manipur, and Tripura, many districts in Meghalaya and Uttarakhand, southern and northern districts of Chhattisgarh, southern Jharkhand, western and north-eastern districts of Odisha, eastern Maharashtra, eastern Madhya Pradesh, eastern and hilly districts of Assam, and few districts in Punjab and Jammu & Kashmir. Tobacco use in any form is higher in most of the districts of north-eastern states,

Odisha, Chhattisgarh, central districts of Madhya Pradesh, Uttar Pradesh, southern districts of Jharkhand, northern and western districts of West Bengal, peninsular Gujarat, eastern Rajasthan, and eastern region of Maharashtra.

Daily or weekly consumption of chicken or meat by women was higher in most of the States in southern and north-eastern parts of India. Higher meat consumption was also noted in Jammu & Kashmir, Ladakh, western and coastal Maharashtra, eastern Odisha and southern Jharkhand. Consumption of fried food items was particularly seen in eastern and north-eastern parts of India, notably in West Bengal, Odisha, and all north-eastern states. Fried food consumption is also higher in central districts of Uttar Pradesh, Madhya Pradesh, western Rajasthan, western Gujarat, southern Karnataka, central Andhra Pradesh, and many districts of Kerala. The pattern of consumption of fish is somewhat similar to that of chicken or meat except high prevalence of fish consumption along coastal lines of India and in almost all the districts of Odisha, West Bengal, Kerala, and Tamil Nadu. Consumption of milk and milk products was higher in districts in north and western parts of India, Karnataka, Andhra Pradesh, and southern Telangana. Aerated drinks were commonly consumed in north-eastern states of India, Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Jammu & Kashmir, Ladakh, northern districts in Maharashtra, and districts along border of Uttar Pradesh and Bihar. The percentage of households with any woman age 15 to 49 being overweight/obese is typically higher in northern and southern states of India along with Sikkim, Arunachal Pradesh, and western districts of Maharashtra and Gujarat.

The spatial pattern of higher prevalence of clustering of hypertension within households across districts in India showed good overlap with districts with high use of tobacco and overweight/obesity. The overlap with tobacco use is particularly observed in Chhattisgarh, Odisha, Jharkhand, Madhya Pradesh, coastal Gujarat, eastern Rajasthan, and north-eastern states of India. The overlap with overweight/obesity is typically seen in districts in northern and southern parts of India. The districts with higher prevalence of clustering for diabetes demonstrated good overlap with obesity, consumption of fish, and fried food. The districts with high prevalence of any woman being overweight or obese within household matched very closely with districts with higher prevalence of clustering for diabetes. There is remarkable overlap with fish consumption, seen in almost all districts in southern states, West Bengal, north-eastern states, and Odisha. Overlap with consumption of fried food is seen in central districts of Tripura, Mizoram, West Bengal, Rajasthan, Gujarat, pockets in Madhya Pradesh,

and districts along Uttar Pradesh-Bihar border. Overlap of higher prevalence of diabetes clustering was seen with high prevalence of consumption of alcohol in southern, eastern, and north-eastern states whereas to some extent overlap was seen with aerated drinks and diabetes clustering in districts in peninsular Gujarat, central Rajasthan, and districts along Uttar Pradesh-Bihar border.

Household level clustering of hypertension and diabetes was further examined by four-level random intercept logistic regressions; results are shown in **Table 4** and **Table 5**, respectively. With complete sample of all households with BP and RBG measurements, the estimates of clustering of these diseases within households in null model indicate considerable variations at community, district and state level with intraclass correlation coefficient (ICC) of 0.09 at community, 0.02 at district, and 0.03 at state level for hypertension clustering and ICC of 0.08 at community, 0.03 at district, and 0.05 at state level for diabetes clustering. Community, district and state explained considerable variation in hypertension and diabetes clustering even after inclusion of socio-economic, demographic and residence-related characteristics in the regressions.

A number of socio-economic, demographic and residence-related characteristics of the households were associated with clustering of hypertension and diabetes. The odds of clustering of hypertension increased with the increase in number of household members consuming alcohol. For example, a household with three or more members consuming alcohol was 1.79 (95% CI: 1.69-1.89) times as likely as a household with no member consuming alcohol to have clustering of hypertension. Likewise, a household with three or more members using tobacco was 2.32 (95% CI: 2.24-2.40) times as likely as a household with no member using tobacco to have clustering of hypertension. The clustering of hypertension also increased with increase in the share of 15 years and above members in the household (odds ratio - 4.30; 95% CI: 4.13-4.47). The odds of hypertension clustering were negatively associated with the education of the household head. Households with head having secondary or more education were 0.86 (95% CI: 0.84-0.89) times as likely as households with head having no or below primary education to have clustering of hypertension. Clustering of hypertension increased monotonically with increase in household wealth. Compared to lowest wealth quintile households, the odds of clustering of hypertension was 1.36 (95% CI: 1.32-1.40), 1.83 (95% CI: 1.78-1.88), 2.56 (95% CI: 2.48-2.63) and 3.71 (95% CI: 3.59-3.84) times higher among second, middle, fourth and highest wealth quintile households, respectively. The odds of

clustering of hypertension varied by the caste of household head. Households headed by OBC and other castes were more likely than households headed by ST to have clustering of hypertension. Interestingly, the odds of clustering of households was lower in urban (odds ratio – 0.90; 95% CI: 0.88-0.93) than in rural areas. Increase in pucca houses in the community reduced the odds (odds ratio – 0.91; 95% CI: 0.86-0.95) of clustering of hypertension.

Similar associations were observed for clustering of diabetes. The odds of clustering of diabetes increased with the increase in number of household members consuming alcohol; a household with three or more members consuming alcohol was 1.33 (95% CI: 1.23-1.43) times as likely as a household with no member consuming alcohol to have clustering of diabetes. Similarly, a household with three or more members using tobacco was 2.44 (95% CI: 2.34-2.55) times as likely as a household with no member using tobacco to have clustering of diabetes. The clustering of diabetes also increased with increase in the share of 15 years and above members in the household (odds ratio – 3.42; 95% CI: 3.27-3.59). Unlike hypertension clustering, no association was observed between education of the head of the household and diabetes clustering. Clustering of diabetes steadily increased with increase in household wealth. With reference to lowest wealth quintile households, the odds of clustering of diabetes was 1.41 (95% CI: 1.36-1.46), 1.95 (95% CI: 1.87-2.03), 2.86 (95% CI: 2.74-2.99) and 4.28 (95% CI: 4.08-4.51) times higher among second, middle, fourth and highest wealth quintile households, respectively. The odds for diabetes clustering varied by caste of the head of the household. Households headed by other castes and OBC were more likely than households headed by ST to have clustering of hypertension. Interestingly, for diabetes clustering as well, the odds of clustering of households was lower in urban (odds ratio – 0.91; 95% CI: 0.88-0.94) than in rural areas.

With second set of sample of households with BP and RBG measurement and woman's interview, the variations at community, district, and state level for estimates of clustering of hypertension within households remained same with ICC of 0.09 at community, 0.02 at district, and 0.03 at state level in the null model, whereas the variations only at community level for diabetes increased (ICC=0.09) and the variations at district and state level remained unchanged with ICCs of 0.03 and 0.05 respectively. Daily or weekly consumption of milk or milk products (odds ratio - 1.06, $p<0.01$ for hypertension clustering and odds ratio - 1.17, $p<0.01$ for diabetes clustering) and fried food (odds ratio - 1.06, $p<0.01$ each for hypertension clustering and diabetes clustering) were positively associated with clustering of the two NCDs at the

household level. While daily or weekly consumption of fish was positively associated with hypertension clustering (odds ratio - 1.03, p=0.01), the association with diabetes clustering was statistically not significant (odds ratio - 1.03, p=0.08). Interestingly, consumption of aerated drinks was positively associated with diabetes clustering only (odds ratio - 1.03, p=0.03). The odds of clustering of hypertension as well as diabetes increased with the presence of any overweight or obese woman age 15-59 in the household (odds ratio - 1.6, p<0.01 for hypertension clustering and odds ratio - 1.56, p<0.01 for diabetes clustering). After inclusion of these variables, odds of diabetes clustering showed significant negative association with the education of the household head. Households with head having secondary or more education was 0.89 (95% CI: 0.85-0.93) times as likely as households with head having no or below primary education to have clustering of diabetes.

The ICCs from the full model indicate that substantial proportion of variations in the prevalence of clustering of hypertension and diabetes within households was due to the community (9% for hypertension and 8% for diabetes), district (2% each for hypertension and diabetes), and state (2% for hypertension and 4% for diabetes).

Discussion

Our study is perhaps the first to examine the distribution of hypertension and diabetes in the context of clustering of these diseases within households at the district-level using a large-scale nationally representative household survey. Both hypertension and diabetes exhibited considerable clustering. Two or more members of a household were identified with hypertension in 14.9% of households and with diabetes in 8.2% households in India. Further hypertension and diabetes were disproportionately concentrated within these clustered households. The 14.9% households with hypertension clustering harboured about half of the total cases of hypertension in India and 8.2% households with diabetes clustering harboured about 40% of total cases of diabetes in India. Though quantitative estimates per se have not been previously reported, available literature provides evidence of unequal distribution of NCDs and clustering of risk factors within households.[1,3,24,46–48] Given that the large amount of disease burden is nested within the clustered households, proper understanding of the epidemiology of hypertension and diabetes in India and efficient planning of health care for these diseases warrants providing due diligent attention to the phenomenon of clustering.

Huge variation was seen in the prevalence of clustering across the 640 districts of India. The prevalence of hypertension clustering varied from around 3.9% in Kaushambi to around 37.3% in Amritsar and that for diabetes clustering varied from 1.4% in Kra Daadi to 25.0% in Mahe. The spatial distribution of clustering of hypertension and diabetes also demonstrated distinct pockets of high prevalence of clustering. Prioritizing and targeting such areas with high case burden for intensified surveillance and improved disease management can yield better results and accelerate progress towards Sustainable Development Goal 3 (SDG3).

Remarkably, the spatial pattern of districts with higher clustering of hypertension and diabetes overlapped quite well with spatial patterns of districts having high prevalence of various risk factors like alcohol consumption, tobacco use, overweight or obesity and consumption of various types of food items providing potential explanations for clustering in different regions. The higher clustering of diabetes and hypertension in coastal areas could be due to the greater consumption of fish and fried food. Similarly, the regions with higher clustering of hypertension and diabetes in southern, northern, and western regions can be due to higher prevalence of overweight or obesity. Higher clustering for hypertension in central and north-eastern parts of India can be due to higher prevalence of use of tobacco whereas higher clustering in Goa and northern states like Punjab and Himachal Pradesh can be due higher consumption of alcohol. Higher clustering of diabetes in southern, eastern, and north-eastern states can be due to higher alcohol consumption whereas that in Saurashtra region of Gujarat and westerns districts of Bihar can be due to higher consumption of aerated drinks.

The observations from spatial patterns were very well supported by findings from the random intercept models. The regressions at national level revealed that the odds for clustering of hypertension and diabetes increased with increase in number of household members engaged in consumption of alcohol and use of tobacco. Clustering of both the diseases was positively associated with presence of any overweight or obese woman in the household, which can serve as a proxy for other household members' BMI, given the documented concordance of high BMI within couples.[14,31,49,50] The corroboration of diabetes clustering along India's coastline and adjoining states and higher consumption fish and fried food in the same region is particularly notable. This is in accordance with existing literature associating fried fish consumption with development of type II diabetes.[51–55] Fish consumption was also associated with hypertension clustering, consistent with evidence supporting association of hypertension with consumption of dried fish, also a common practice in India.[52,56,57]

However, the NFHS-5 questionnaire did not collect separate information on consumption of dried fish, making it difficult to draw any such correlation. These associations, though interesting, demand further investigation. These findings can strengthen public health interventions and policies by providing key insights about specific risk factors driving clustering in different regions to effectively formulate region-specific interventions.

The clustering for hypertension as well as diabetes within household was positively and significantly associated with percent share of members age 15 years and above in the household, household wealth quintile, rural residence, households where heads belonged to Sikh religion and OBC or *other* castes, and low education of head of the households. Overall similar associations were observed for disease prevalence among individuals as well as concordant couples.[19–22,30] Population ageing is on the rise in India, particularly pronounced in the southern states where higher prevalence of clustering is noticed.[58] With ageing population, the clustering phenomenon is expected to intensify. Such clustering is likely to put tremendous strain on these households, increasing demands for healthcare, social support, and financial resources to cover all care-related costs.

Though overall individual prevalence of hypertension and diabetes is lower in rural than urban areas, clustering for hypertension and diabetes within households was more likely in rural areas.[7,8,39,59] In rural parts of India, homophily in settlements and a large number of households within a community belonging to same patrilineage are not uncommon.[60] Such a pattern of settlement may result in culmination of genetic as well as socio-environmental factors which can result in higher clustering in rural than in urban areas. While this finding is interesting, it requires further investigation. The higher likelihood of clustering of hypertension and diabetes in rural households poses a big challenge for health systems to deliver health care in rural areas as advanced interventions, diagnostics, and expertise will be potentially required to manage these conditions, prevent complications, and ultimately to avoid mortality. The health care system needs to be adequately bolstered to deliver services for NCDs in rural areas. Our finding also underscores the need to integrate specialised care with primary health care and expansion of outreach of specialised care by various means. Low level of education of head of households further exacerbates the vulnerability of the clustered households to complications of these diseases. This is due to lack of awareness about diseases, inability to identify complications, and difficulties in seeking, accessing, and adhering to treatment. To address this issue, initiative for creating awareness and imparting relevant knowledge must be

tailored to suit to the specific needs of the target audience and should be effectively implemented.

The odds for clustering of hypertension and diabetes was more among households belonging to higher wealth quintiles. While wealthier households are more likely to be aware about hypertension and diabetes and seek treatment, even among this group the awareness, treatment and control of these conditions is far from satisfactory.[7,8] This suggests there is considerable potential for improved health outcomes through targeted awareness, treatment and control activities even among wealthier households. The situation is potentially more drastic for households belonging to deprived sections of the society. Although these households exhibit lower clustering prevalence, when affected, they are likely to have lower awareness, treatment and control.[7,8,59] Failure to promptly manage hypertension and diabetes may eventually lead to disproportionate clustering of deaths due to cardiovascular events and other complications within clustered households.

The interactions and interplay of various factors contributing to clustering and the variations in amount of clustering at community, district, and state level was analysed using random intercept regressions. The results demonstrate considerable inequality; hypertension and diabetes clustering being affected by community and the state. The ICC for hypertension and diabetes was highest at the community level indicating the highest impact of factors in the immediate neighbourhood like common shared environment, similar food patterns, settlement patterns, and socio-cultural practices associated with high risk behaviours. These findings are in accordance with previous studies that have suggested influence of immediate neighbourhood on risks associated with NCDs, though evidence from India is limited.[61–63]

The present study has some limitations. We identified diabetes based on values of random blood glucose which are less reliable than glycated haemoglobin or fasting blood glucose. Collecting these biomarkers in NFHS like survey with vast geographical expanse and large sample size have operational and economic limitations. Though technically it was feasible to segregate respondents with 8 hours fasting, we did not attempt it because NFHS-5 was not designed for fasting blood collection like other DHS surveys where respondents were prior informed to remain fasted and later blood glucose was tested.[64] Also, segregating fasting individuals would reduce sample size, particularly affecting the within household analysis. The reported consumption of various food items can be affected by recall bias. BMI information was not

available for all adult members of the household and we considered woman's BMI as proxy for all other members. NFHS being a cross sectional survey, the scope for any causal analysis is limited. The age of onset of hypertension and diabetes are not available in NFHS-5 limiting any additional analysis. Also, information on some important indicators like physical activity and amount of daily salt consumption was not collected in NFHS-5. The analysis based on complete sample and sub-sample may not be strictly comparable due to difference in the age-structure of the members. However, this is less problematic given that the mean age of members in the full sample (39.5 years) was only 2 years more than that of the sub-sample (37.5 years). While we found association of fish consumption with hypertension, we could not differentiate whether it was consumption of dried fish as this information was not collected in NFHS-5.

Our study findings provide crucial insights about district-wise distribution of hypertension and diabetes in India with a unique context of clustering of these diseases within households using large-scale nationally representative survey. We emphasize high priority areas for intensified interventions aimed at raising awareness, rapid case detection, and adequate management of hypertension and diabetes to ensure rapid advancements towards SDG 3. Taking cognizance of clustering of NCDs is particularly important in low resource settings, such as LMICs, where identifying and focusing on high priority areas can yield higher dividends. Our study quantitatively estimates the clustering within households, providing empirical evidence in support of family level interventions for efficient and rapid management of hypertension and diabetes. The varied case burden across different districts and regions, as indicated by prevalence of clustered households, strongly advocates for customised district- and region-specific policy formulation. The distinct spatial distribution patterns of clustering of hypertension and diabetes aligned with the distribution of overweight or obesity, consumption of alcohol and tobacco, and consumption of fish and fried food, suggesting important region-specific associations with clustering, which can be further evaluated and utilized to plan interventions for prevention, education, screening, and treatment. The evidence generated by our study should also be useful in exploring the potential of community-based interventions for management of hypertension and diabetes in India. Additionally, our study offers recommendations for The DHS programme. DHS being a valuable dataset on NCDs and their risk factors for evidence-based policy making for many developing countries, should collect information on weight and height measurement for all household members aged15 years and above, in addition to blood pressure and blood glucose measurement. DHS should also strive to collect relevant information on NCDs, such as daily salt consumption, the timing of onset or

diagnosis of hypertension and diabetes, and levels of physical activity. Further, collection of community data in DHS surveys may enrich analysis of the NCDs. Our analytical approach can serve as a model for other LMICs, where DHS or similar surveys are conducted at regular intervals. By adapting to our analysis, these countries may gain deeper insights into the epidemiology of hypertension and diabetes within their specific contexts.

Declaration of competing interests: We declare no competing interests.

Data sharing: National Family Health Survey-5 data used in this study, are publicly available at https://dhsprogram.com/data/available-datasets.cfm.

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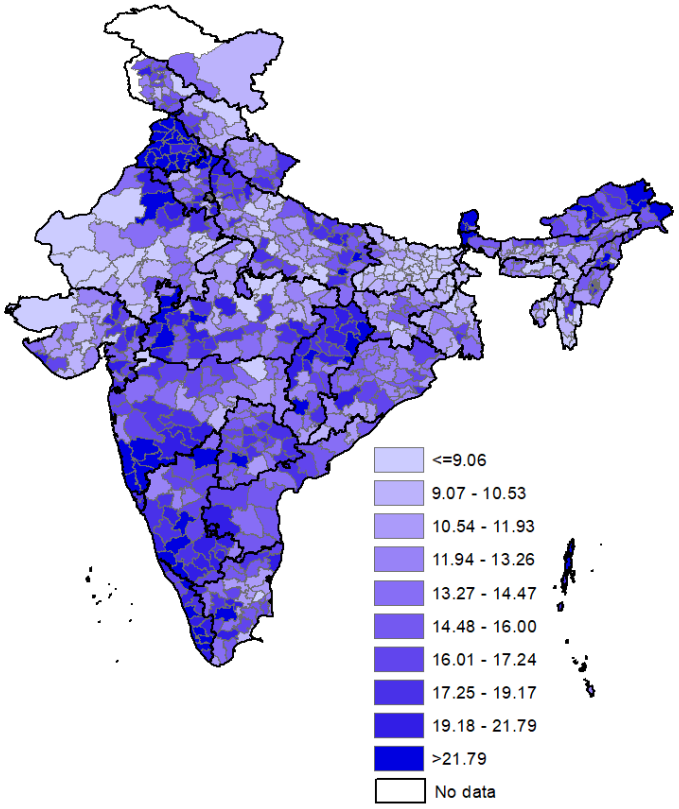


Figure 1: Spatial distribution of households with clustering of hypertension

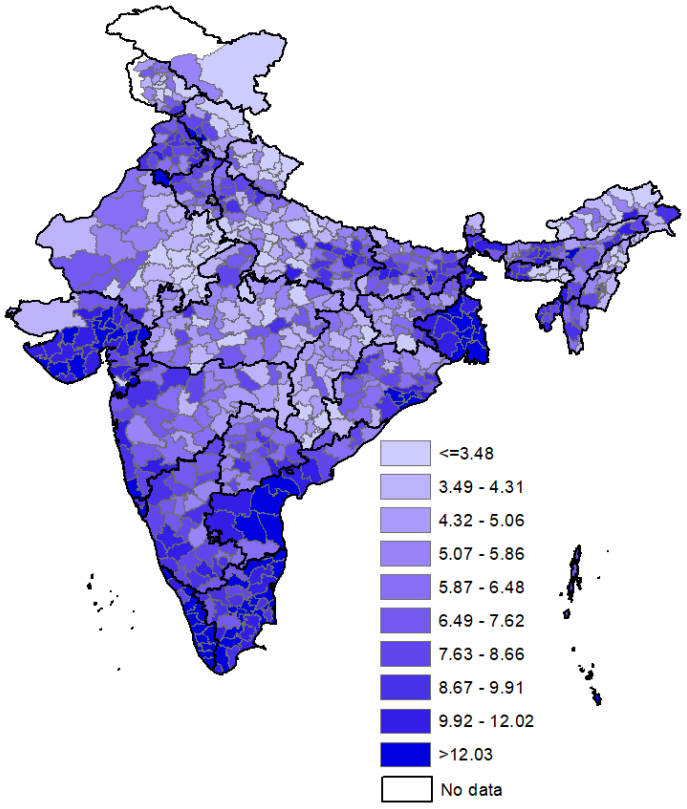


Figure 2: Spatial distribution of households with clustering of diabetes

Table 1: Sample characteristics

	Household analysed for Hypertension clustering		Household analysed for Diabetes clustering		Household analysed for Hypertension clustering [@]		Household analysed for Diabetes clustering [@]	
	%/Mean	95%CI	%/Mean	95%CI	%/Mean	95%CI	%/Mean	95%CI
Number of household member drink alcohol (%)								
No member	73.1	(73-73.2)	73.0	(72.9-73.1)	72.1	(72-72.2)	72.0	(71.9-72.1)
One member	22.5	(22.4-22.7)	22.6	(22.5-22.7)	23.3	(23.2-23.4)	23.4	(23.2-23.5)
Two members	3.5	(3.4-3.5)	3.5	(3.4-3.5)	3.7	(3.6-3.7)	3.7	(3.6-3.7)
Three and more members	0.9	(0.8-0.9)	0.9	(0.8-0.9)	0.9	(0.9-1)	0.9	(0.9-1)
Number of household member smokes and/or use tobacco								
No member	46.6	(46.5-46.7)	46.5	(46.4-46.6)	45.3	(45.2-45.5)	45.3	(45.1-45.4)
One member	36.6	(36.4-36.7)	36.6	(36.5-36.7)	36.8	(36.7-37)	36.9	(36.7-37)
Two members	12.3	(12.2-12.4)	12.4	(12.3-12.4)	12.8	(12.7-12.9)	12.8	(12.7-12.9)
Three and more members	4.5	(4.5-4.6)	4.5	(4.5-4.6)	5.1	(5-5.1)	5.1	(5-5.1)
Percentage share of 15+ aged member in the household (mean)	77.9	(77.8-77.9)	77.8	(77.8-77.9)	73.8	(73.7-73.8)	73.8	(73.7-73.8)
Household head education (%)								
No education or below primary	28.7	(28.6-28.8)	28.6	(28.5-28.7)	27.0	(26.9-27.1)	27.0	(26.9-27.1)
Primary completed	18.8	(18.7-18.9)	18.8	(18.7-18.9)	18.6	(18.5-18.8)	18.7	(18.6-18.8)
Secondary completed	42.0	(41.9-42.1)	42.1	(41.9-42.2)	44.1	(44-44.2)	44.1	(44-44.2)
Higher secondary and above	10.5	(10.4-10.6)	10.5	(10.4-10.6)	10.3	(10.2-10.3)	10.2	(10.1-10.3)
Household belonged to wealth quintile (%)								
Lowest	21.1	(21-21.2)	21.1	(21-21.2)	19.9	(19.8-20)	19.9	(19.8-20.1)
Second	20.3	(20.2-20.4)	20.3	(20.2-20.5)	20.4	(20.3-20.5)	20.4	(20.3-20.5)
Middle	20.2	(20.1-20.3)	20.3	(20.2-20.4)	20.6	(20.5-20.7)	20.6	(20.5-20.7)
High	19.6	(19.5-19.7)	19.6	(19.5-19.7)	20.3	(20.2-20.4)	20.3	(20.2-20.4)
Highest	18.7	(18.6-18.8)	18.6	(18.5-18.7)	18.8	(18.7-18.9)	18.7	(18.6-18.9)
Social group of household head (%)								
Scheduled Tribe	9.7	(9.6-9.7)	9.7	(9.6-9.8)	9.9	(9.8-10)	9.9	(9.9-10)
Scheduled Caste	21.8	(21.7-21.9)	21.9	(21.8-22)	22.3	(22.2-22.4)	22.3	(22.2-22.5)
OBC	41.7	(41.5-41.8)	41.6	(41.5-41.8)	41.5	(41.4-41.7)	41.5	(41.4-41.7)
Other caste	26.8	(26.7-26.9)	26.8	(26.7-26.9)	26.2	(26.1-26.3)	26.2	(26.1-26.3)
Religion household head (%)								
Other religion	1.3	(1.3-1.3)	1.3	(1.3-1.3)	1.3	(1.2-1.3)	1.3	(1.2-1.3)
Hindu	82.2	(82.1-82.3)	82.3	(82.2-82.4)	81.6	(81.5-81.7)	81.7	(81.6-81.8)
Muslim	12.2	(12.1-12.3)	12.1	(12-12.2)	13.1	(13-13.2)	13.0	(12.9-13.1)
Christian	2.8	(2.8-2.9)	2.8	(2.8-2.8)	2.6	(2.5-2.6)	2.6	(2.5-2.6)
Sikh	1.5	(1.4-1.5)	1.4	(1.4-1.5)	1.5	(1.4-1.5)	1.5	(1.4-1.5)
Rural residence (%)								
Urban	32.1	(32-32.2)	32.0	(31.9-32.2)	31.6	(31.4-31.7)	31.5	(31.4-31.6)
Rural	67.9	(67.8-68)	68.0	(67.8-68.1)	68.4	(68.3-68.6)	68.5	(68.4-68.6)
Pucca household in a Primary Sampling Unit (Mean)	59.7	(59.7-59.8)	59.7	(59.6-59.8)	58.7	(58.6-58.8)	58.7	(58.6-58.7)

	Household analysed for Hypertension clustering		Household analysed for Diabetes clustering		Household analysed for Hypertension clustering @		Household analysed for Diabetes clustering @	
	%/Mean	95%CI	%/Mean	95%CI	%/Mean	95%CI	%/Mean	95%CI
Consumption of milk or milk products by women (%)					75.2	(75.1-75.3)	75.2	(75.1-75.3)
Consumption of fish by women (%)					40.0	(39.9-40.2)	40.0	(39.9-40.2)
Consumption of meat by women (%)					40.1	(40-40.2)	40.1	(39.9-40.2)
Consumption of fried food by women (%)					47.3	(47.1-47.4)	47.3	(47.1-47.4)
Consumption of aerated drink by women (%)					18.0	(17.9-18.1)	18.0	(17.9-18.1)
Presence of any overweight/obese woman in the household (%)					30.4	(30.3-30.6)	30.4	(30.3-30.5)
Number	**619839**		**615125**		**500267**		**497949**	

Note: @ in the sub-sample households where interview of any eligible woman (15-49 years) was completed

Table 2: Percentage distribution of households with number of members identified with hypertension and diabetes along with the proportion of total cases nested within the household

Hypertension clustering				Diabetes clustering			
No. of HH members identified with hypertension	**Percentage of total HHs**	**Number of households for hypertension**	**Proportion of total case burden of hypertension**	**No. of HH members identified with Diabetes**	**Percentage of total HHs**	**Number of households for Diabetes**	**Proportion of total case burden of Diabetes**
0	53.2	318683	0	0	65.2	400951	
1	32.4	208690	50.2	1	26.6	163738	59.8
2	11.6	74440	35.8	2	6.9	42589	31.1
3	2.3	14659	10.6	3	1.1	6603	7.2
4	0.4	2718	2.6	4	0.2	1036	1.5
5	0.1	520	0.6	5	0.0	164	0.3
6 +	0	130	0.0	6 +	0.0	45	0.1
Total Households with clustering	14.9	92466	49.6	Total Households with clustering	8.2	50436	40.2

Table 3: Prevalence of clustering of hypertension and diabetes by selected household characteristics

	Hypertension clustering in the household		Diabetes clustering in the household		Hypertension clustering in the household @		Diabetes clustering in the household @	
	%	95%CI	%	95%CI	%	95%CI	%	95%CI
Number of household member drink alcohol								
No member	14.6	(14.5,14.8)	8.4	(8.3,8.6)	14.3	(14.2,14.5)	8.3	(8.2,8.4)
One member	14.3	(14.1,14.6)	7.1	(6.9,7.3)	13.9	(13.7,14.2)	7	(6.8,7.2)
Two members	21.7	(21.1,22.4)	9.5	(9.0,10.0)	21.8	(21.0,22.5)	9.8	(9.3,10.4)
Three and more members	26.4	(25.1,27.8)	12	(10.9,13.1)	27.3	(25.8,28.7)	12.1	(11.0,13.2)
Number of household member smoke and/or use tobacco								
No member	14.9	(14.7,15.0)	8.5	(8.3,8.6)	14.4	(14.2,14.6)	8.1	(8.0,8.3)
One member	13.1	(13.0,13.3)	7	(6.9,7.2)	12.9	(12.7,13.1)	7	(6.8,7.2)
Two members	17.4	(17.1,17.8)	9	(8.8,9.3)	17.1	(16.8,17.5)	9.2	(8.9,9.5)
Three and more members	23	(22.4,23.6)	12.5	(12.0,13.0)	23.2	(22.6,23.9)	12.9	(12.4,13.5)
Household head's education								
No education or below primary	12.8	(12.6,13.0)	6.4	(6.2,6.5)	13.2	(13.0,13.4)	6.7	(6.5,6.9)
Primary completed	15.3	(15.0,15.6)	8.3	(8.1,8.5)	14.8	(14.5,15.1)	8.3	(8.0,8.5)
Secondary completed	15.7	(15.5,15.9)	8.9	(8.7,9.1)	15	(14.8,15.2)	8.5	(8.4,8.7)
Higher secondary and above	17	(16.5,17.4)	10.3	(9.9,10.7)	16.4	(15.9,16.9)	9.7	(9.3,10.1)
Household belonged to wealth quintile								
Lowest	8.8	(8.6,9.0)	4.5	(4.4,4.7)	8.2	(8.0,8.5)	4.6	(4.4,4.8)
Second	11.7	(11.5,11.9)	6	(5.8,6.2)	11.4	(11.1,11.6)	6.1	(5.9,6.3)
Middle	14.7	(14.4,15.0)	7.8	(7.6,8.1)	14.5	(14.2,14.8)	7.7	(7.5,8.0)
Higher	18.1	(17.8,18.4)	10.3	(10.1,10.6)	17.7	(17.3,18.0)	10	(9.7,10.3)
Highest	22.2	(21.9,22.6)	12.9	(12.6,13.2)	21.8	(21.4,22.2)	12.3	(12.0,12.6)
Social group of household head								
Scheduled Tribe	12.9	(12.6,13.2)	5.3	(5.1,5.5)	12.7	(12.4,13.1)	5.4	(5.1,5.6)
Scheduled Caste	13.2	(12.9,13.4)	6.8	(6.6,7.0)	12.9	(12.6,13.2)	6.8	(6.5,7.0)
OBC	14.9	(14.7,15.1)	8.4	(8.2,8.5)	14.7	(14.5,14.9)	8.2	(8.1,8.4)
Other caste	17.1	(16.9,17.4)	10.2	(9.9,10.4)	16.7	(16.4,17.0)	10	(9.8,10.3)
Religion of household head								
Other religion	15.2	(14.1,16.4)	6	(5.2,6.9)	15.1	(13.8,16.4)	6	(5.1,7.0)
Hindu	14.8	(14.6,14.9)	8.1	(8.0,8.2)	14.5	(14.4,14.7)	8	(7.9,8.1)
Muslim	13.6	(13.3,14.0)	8.5	(8.2,8.9)	13.3	(12.9,13.6)	8.6	(8.3,9.0)
Christian	17.3	(16.5,18.1)	10.7	(10.0,11.4)	16.1	(15.2,17.0)	10	(9.3,10.8)
Sikh	29.4	(28.4,30.3)	8.5	(8.0,9.1)	30	(28.9,31.0)	8.5	(7.9,9.1)
Residence								
Urban	17.1	(16.8,17.4)	10.1	(9.9,10.3)	16.7	(16.4,17.0)	9.8	(9.6,10.1)
Rural	13.9	(13.8,14.0)	7.3	(7.2,7.4)	13.7	(13.5,13.8)	7.3	(7.2,7.4)
Household consume milk or milk products daily or weekly								
No					12.1	(11.9,12.4)	6.4	(6.2,6.6)
Yes					15.4	(15.3,15.6)	8.7	(8.5,8.8)

	Hypertension clustering in the household		Diabetes clustering in the household		Hypertension clustering in the household [@]		Diabetes clustering in the household [@]	
	%	95%CI	%	95%CI	%	95%CI	%	95%CI
Household consume fish daily or weekly								
No					14.6	(14.5,14.8)	7	(6.9,7.1)
Yes					14.6	(14.4,14.8)	9.7	(9.5,9.9)
Household consume chicken or meat daily or weekly								
No					14.5	(14.3,14.6)	7.3	(7.2,7.5)
Yes					14.9	(14.6,15.1)	9.2	(9.0,9.4)
Household consume fried foods daily or weekly								
No					14.1	(13.9,14.3)	7.3	(7.2,7.5)
Yes					15.2	(15.0,15.4)	8.9	(8.8,9.1)
Household consume aerated drinks daily or weekly								
No					14.4	(14.2,14.5)	7.8	(7.7,7.9)
Yes					15.9	(15.5,16.2)	9.5	(9.2,9.8)
Presence of any overweight/obese woman in the household								
No					12.1	(11.9,12.2)	6.4	(6.3,6.6)
Yes					20.5	(20.2,20.8)	11.9	(11.7,12.2)

Note: [@] in the sub-sample households where interview of any eligible woman (15-49 years) was completed

Table 4: Estimates from four-level random intercept model

	Hypertension clustering at household								Diabetes clustering at household							
	Null Model				Full Model				Null Model				Full Model			
	OR	p-value	[95% CI]		OR	p-value	[95% CI]		OR	p-value	[95% CI]		OR	p-value	[95% CI]	
Constant	0.16	<0.001	0.15	0.17	0.02	<0.001	0.02	0.02	0.07	<0.001	0.06	0.07	0.01	<0.001	0.01	0.01
Number of household member drink alcohol																
No member®																
One member					0.98	0.0170	0.96	1.00					0.91	<0.001	0.88	0.93
Two members					1.39	<0.001	1.35	1.44					1.07	0.0040	1.02	1.12
Three and more members					1.79	<0.001	1.69	1.89					1.33	<0.001	1.23	1.43
Number of household member smoke and/or use tobacco																
No member®																
One member					1.10	<0.001	1.08	1.12					1.11	<0.001	1.08	1.14
Two members					1.58	<0.001	1.55	1.62					1.61	<0.001	1.55	1.66
Three and more members					2.32	<0.001	2.24	2.40					2.44	<0.001	2.34	2.55
Percentage share of 15+ aged member in the household					4.30	<0.001	4.13	4.47					3.42	<0.001	3.27	3.59
Household head's education																
No education or below primary®																
Primary completed					1.08	<0.001	1.05	1.10					1.06	<0.001	1.03	1.09
Secondary completed					0.96	<0.001	0.95	0.98					1.01	0.3180	0.98	1.04
Higher secondary and above					0.86	<0.001	0.84	0.89					0.96	0.0290	0.92	1.00
Household belonged to wealth quintile																
Lowest®																
Second					1.36	<0.001	1.32	1.40					1.41	<0.001	1.36	1.46
Middle					1.83	<0.001	1.78	1.88					1.95	<0.001	1.87	2.03
Higher					2.56	<0.001	2.48	2.63					2.86	<0.001	2.74	2.99
Highest					3.71	<0.001	3.59	3.84					4.28	<0.001	4.08	4.51
Social group of household head																
Scheduled Tribe®																
Scheduled Caste					0.98	0.1300	0.95	1.02					1.04	0.0440	0.99	1.09
OBC					1.07	<0.000	1.04	1.11					1.17	<0.000	1.12	1.22
Other caste					1.14	<0.001	1.10	1.18					1.24	<0.001	1.18	1.30
Religion of household head																
Other religion®																
Hindu					0.99	0.4050	0.95	1.04					1.08	0.0420	0.99	1.17
Muslim					0.96	0.0940	0.91	1.02					1.04	0.2040	0.95	1.14
Christian					1.02	0.3020	0.96	1.08					1.04	0.1640	0.96	1.14
Sikh					1.21	<0.001	1.11	1.31					1.32	<0.001	1.16	1.48
Place of residence																
Rural®																
Urban					0.90	<0.001	0.88	0.93					0.91	<0.001	0.88	0.94
Pucca household in a Primary Sampling Unit					0.91	<0.001	0.86	0.95					0.93	0.0230	0.88	1.00

	Variance	ICC	Variance	ICC	Variance	ICC	Variance	ICC
State	0.12	0.03	0.08	0.02	0.19	0.05	0.16	0.04
District	0.09	0.02	0.09	0.02	0.10	0.03	0.09	0.02
Primary Sampling Unit	0.33	0.09	0.33	0.09	0.31	0.08	0.28	0.07
Residual	3.29		3.29		3.29		3.29	

Note: OR-Odds Ratio; CI-Confidence Interval; ICC-Intra Class Correlation; ® Reference category

Table 5: Estimates from four-level random intercept model (sub-sample households where interview of any eligible woman (15-49 years) was completed)

	Hypertension clustering at household								Diabetes clustering at household							
	Null Model				Full Model				Null Model				Full Model			
	OR	p-value	[95% CI]		OR	p-value	[95% CI]		OR	p-value	[95% CI]		OR	p-value	[95% CI]	
Constant	0.15	<0.001	0.14	0.16	0.02	<0.001	0.02	0.02	0.07	0.00	0.06	0.07	0.01	<0.001	0.01	0.01
Number of household member drink alcohol																
No member®																
One member					0.97	0.007	0.95	0.99					0.90	<0.001	0.87	0.93
Two members					1.39	<0.001	1.33	1.44					1.09	<0.001	1.03	1.15
Three and more members					1.79	<0.001	1.69	1.90					1.31	<0.001	1.21	1.42
Number of household member smoke and/or use tobacco																
No member®																
One member					1.11	<0.001	1.09	1.13					1.12	<0.001	1.09	1.16
Two members					1.57	<0.001	1.52	1.61					1.60	<0.001	1.54	1.66
Three and more members					2.32	<0.001	2.23	2.40					2.42	<0.001	2.31	2.54
Percentage share of 15+ aged member in the household					4.64	<0.001	4.44	4.85					3.73	<0.001	3.50	3.96
Household head's education																
No education or below primary®																
Primary completed					1.00	0.436	0.98	1.03					1.01	0.298	0.97	1.05
Secondary completed					0.88	<0.001	0.86	0.90					0.93	<0.001	0.90	0.96
Higher secondary and above					0.80	<0.001	0.77	0.83					0.89	<0.001	0.85	0.93
Household belonged to wealth quintile																
Lowest®																
Second					1.33	<0.001	1.29	1.37					1.32	<0.001	1.26	1.38
Middle					1.71	<0.001	1.66	1.77					1.72	<0.001	1.64	1.81
Higher					2.30	<0.001	2.22	2.38					2.40	<0.001	2.28	2.53
Highest					3.22	<0.001	3.08	3.35					3.42	<0.001	3.20	3.64
Social group of household head																
Scheduled Tribe®																
Scheduled Caste					0.96	0.027	0.93	1.00					1.03	0.157	0.98	1.08
OBC					1.07	<0.001	1.04	1.11					1.16	<0.001	1.11	1.21
Other caste					1.14	<0.001	1.10	1.18					1.24	<0.001	1.18	1.30
Religion of household head					0.98	0.308	0.90	1.06					1.06	0.099	0.98	1.17
Other religion®																
Hindu																
Muslim					0.91	0.017	0.83	0.99					1.00	0.447	0.91	1.12
Christian					0.99	0.451	0.91	1.08					1.03	0.299	0.93	1.14
Sikh					1.21	<0.001	1.07	1.35					1.27	<0.001	1.11	1.46
Place of residence																
Rural®																
Urban					0.90	<0.001	0.87	0.93					0.91	<0.001	0.87	0.94
Pucca household in a Primary Sampling Unit					0.91	<0.001	0.85	0.96					0.96	0.148	0.90	1.03

	Hypertension clustering at household						Diabetes clustering at household					
	Null Model			Full Model			Null Model			Full Model		
	OR	**p-value**	**[95% CI]**	**OR**	**p-value**	**[95% CI]**	**OR**	**p-value**	**[95% CI]**	**OR**	**p-value**	**[95% CI]**
Household consume milk or milk product daily or weekly												
No®												
Yes				1.06	<0.001	1.04 1.08				1.17	<0.001	1.13 1.20
Household consume fish daily or weekly												
No®												
Yes				1.03	0.010	1.00 1.06				1.03	0.083	0.99 1.06
Household consume chicken or meat daily or weekly												
No®										0.99	0.180	0.96 1.02
Yes				0.99	0.183	0.96 1.02						
Household consume fried foods daily or weekly												
No®										1.06	<0.001	1.04 1.09
Yes				1.06	<0.001	1.04 1.08						
Household consume aerated drinks daily or weekly												
No®										1.03	0.030	1.00 1.06
Yes				1.01	0.256	0.98 1.03						
Presence of any overweight/obese woman in the household												
No®												
Yes				1.60	<0.001	1.57 1.63				1.56	<0.001	1.52 1.59
	Variance	ICC		Variance	ICC		Variance	ICC		Variance	ICC	
State	0.12	0.03		0.07	0.02		0.18	0.05		0.15	0.04	
District	0.10	0.02		0.10	0.02		0.10	0.03		0.09	0.02	
Primary Sampling Unit	0.35	0.09		0.34	0.09		0.33	0.09		0.29	0.08	
Residual	3.29			3.29			3.29			3.29		

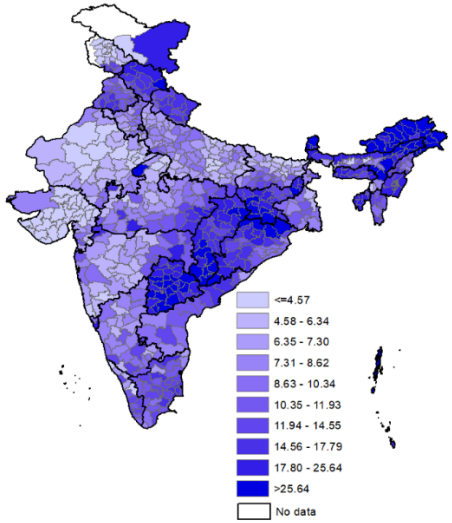
Note: OR-Odds Ratio; CI-Confidence Interval; ICC-Intra Class Correlation; ® Reference category

Supplementary Material

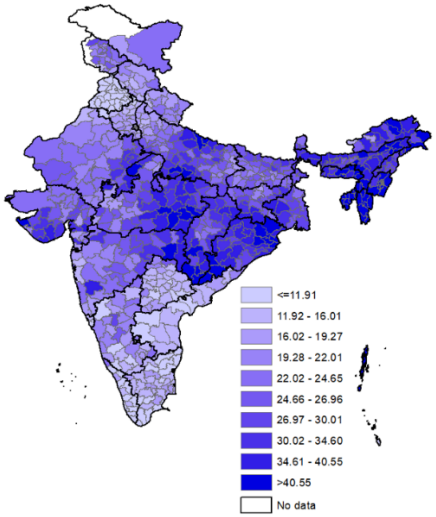
S1: Measurement of weight and height and calculation of BMI

In NFHS-5, weight and height of women age 15-49 years were measured after completion of their individual interview. Weight was measured using Seca 874 weighing scale and height was measured using Seca 217 stadiometer manufactured by Seca GmbH & Co. KG, Germany. Body mass index (BMI) was calculated as weight of a person measured in kilograms divided by squared height of that person measured in meters. Respondents with body mass index (BMI) >/=25 kg/m^2 were considered as Overweight/Obese.

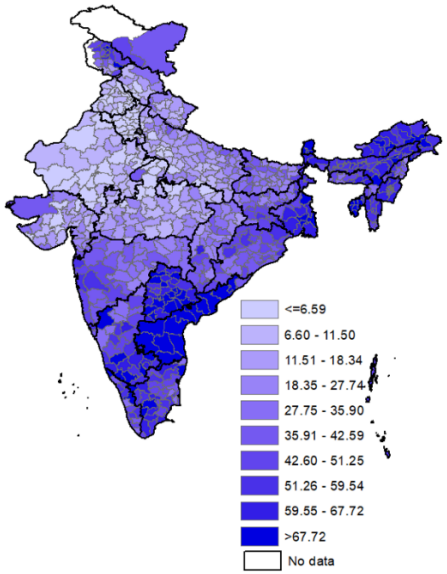
a. Alcohol



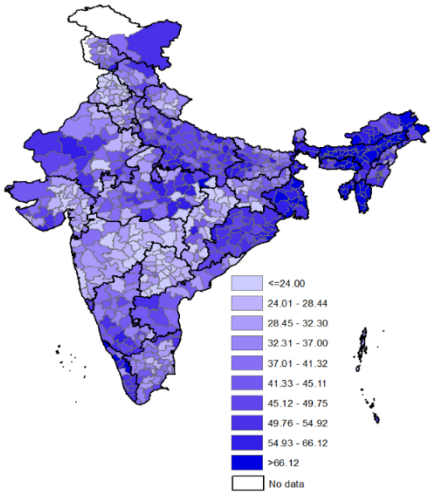
b. Smoke



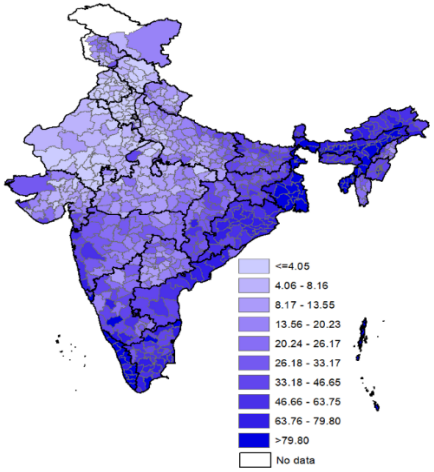
c. Chicken or meat



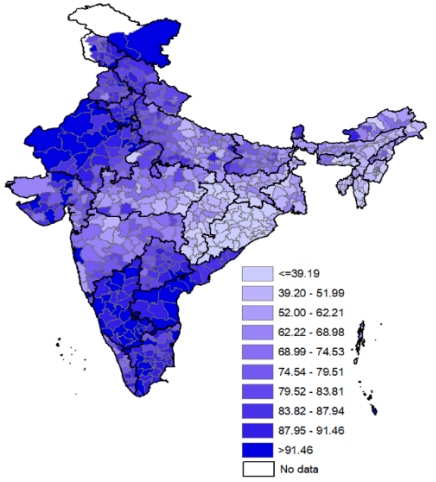
d. Dried food



e. Fish



f. Curd/Milk



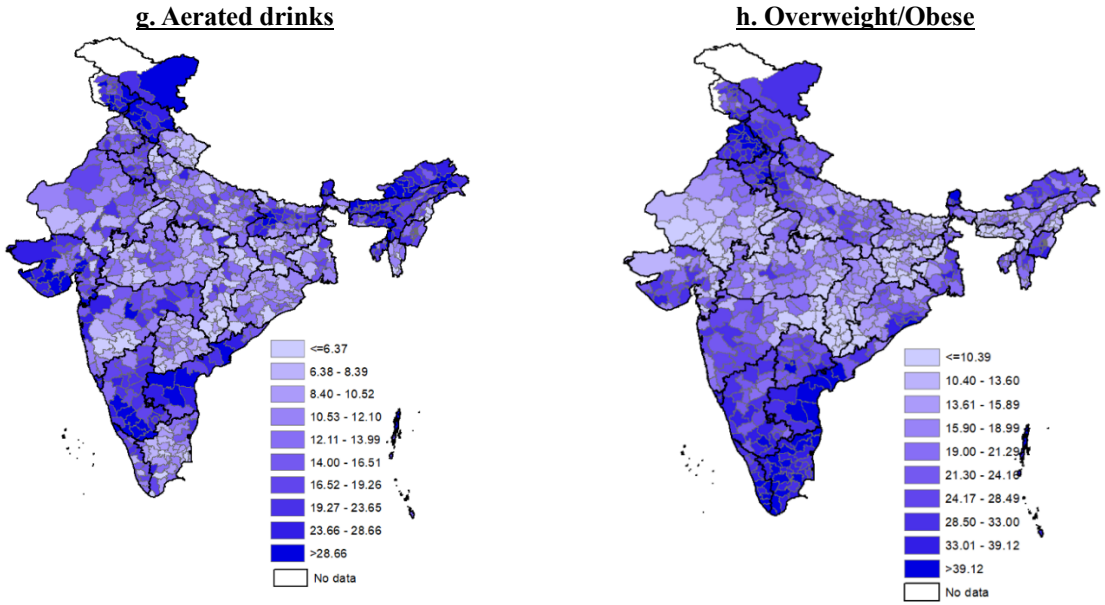


Figure S1: District-wise spatial distribution of percentage of households with any member consuming alcohol, using tobacco, daily or at-least weekly consumption of chicken or meat, fried food, fish, curd or milk, aerated drinks, and percentage of households with at-least one woman obese or overweight

Table S1: District-wise prevalence of households with hypertension and diabetes clusters

District	Hypertension clustering	Diabetes clustering
Kupwara	15.0	4.8
Badgam	17.0	4.4
Leh (Ladakh)	10.1	2.9
Kargil	14.5	5.5
Punch	12.4	3.9
Rajouri	13.3	5.4
Kathua	15.7	9.9
Baramula	19.5	6.9
Bandipore	15.8	6.3
Srinagar	11.8	2.8
Ganderbal	17.6	6.2
Pulwama	17.8	2.2
Shupiyan	9.7	4.0
Anantnag	13.4	6.1
Kulgam	16.5	2.7
Doda	14.9	4.5
Ramban	11.8	2.5
Kishtwar	6.6	3.3
Udhampur	16.4	6.9
Reasi	9.5	3.0
Jammu	14.1	4.4
Samba	16.4	6.4
Chamba	11.3	4.5
Kangra	16.1	7.8
Lahul & Spiti	7.5	2.6
Kullu	10.6	3.3
Mandi	11.5	7.8
Hamirpur	17.4	9.6
Una	18.9	12.4
Bilaspur	12.7	12.1
Solan	11.1	4.5
Sirmaur	14.7	4.8
Shimla	10.2	5.0
Kinnaur	10.0	2.3
Kapurthala	28.5	9.4
Jalandhar	26.8	8.8
Hoshiarpur	37.0	7.9
Shahid Bhagat Singh N	35.5	11.4
Fatehgarh Sahib	25.7	9.9
Ludhiana	21.7	8.1
Moga	33.4	8.8
Muktsar	23.7	8.5
Faridkot	25.5	10.9
Bathinda	34.2	6.2
Mansa	31.6	6.2
Patiala	22.2	9.8
Amritsar	37.3	7.9
Tarn Taran	29.2	5.7
Rupnagar	21.8	12.1
Sahibzada Ajit Singh	22.2	11.1
Sangrur	32.5	5.1
Barnala	32.6	8.2
Chandigarh	16.3	10.3
Uttarkashi	11.9	4.1
Chamoli	12.8	1.8
Rudraprayag	12.3	5.6

District	Hypertension clustering	Diabetes clustering
Tehri Garhwal	12.7	2.7
Dehradun	15.8	7.2
Garhwal	13.1	3.7
Pithoragarh	18.2	2.9
Bageshwar	15.8	3.0
Almora	16.2	3.1
Champawat	15.6	4.0
Nainital	18.4	5.9
Udham Singh Nagar	14.3	7.2
Hardwar	19.4	3.9
Panchkula	15.7	10.5
Ambala	30.1	6.7
Yamunanagar	29.0	9.9
Kurukshetra	33.7	8.1
Kaithal	10.7	8.4
Karnal	16.1	4.9
Panipat	17.6	7.4
Sonipat	15.2	7.2
Jind	11.1	7.2
Fatehabad	10.2	8.7
Sirsa	17.7	14.2
Hisar	15.3	7.7
Rohtak	17.2	8.5
Jhajjar	19.8	6.1
Mahendragarh	18.8	5.3
Rewari	19.6	3.8
Gurgaon	10.1	6.4
Mewat	11.3	3.1
Faridabad	20.2	6.7
Palwal	21.0	6.3
Ganganagar	13.5	6.2
Hanumangarh	19.3	4.9
Bikaner	8.5	6.0
Churu	22.7	4.2
Jhunjhunun	20.1	4.2
Alwar	17.6	1.6
Bharatpur	15.4	3.1
Dhaulpur	7.4	2.9
Karauli	6.3	2.6
Sawai Madhopur	9.7	2.4
Dausa	8.9	4.0
Jaipur	10.6	4.0
Sikar	17.9	4.7
Nagaur	13.5	5.3
Jodhpur	11.9	5.1
Jaisalmer	8.2	3.8
Barmer	6.6	7.6
Jalor	7.0	7.6
Sirohi	11.3	2.1
Pali	8.6	7.1
Ajmer	8.8	3.1
Tonk	14.2	2.8
Bundi	14.0	3.1
Bhilwara	9.6	3.8
Rajsamand	10.3	3.1
Dungarpur	8.9	9.5
Banswara	11.9	4.9
Chittaurgarh	14.5	4.2

District	Hypertension clustering	Diabetes clustering
Kota	14.2	3.3
Baran	9.4	2.5
Jhalawar	13.1	4.0
Udaipur	10.5	5.2
Pratapgarh	10.4	3.7
Saharanpur	21.1	6.1
Bijnor	16.9	8.2
Rampur	12.6	8.7
Jyotiba Phule Nagar	18.6	3.8
Meerut	16.5	8.7
Baghpat	19.4	7.6
Gautam Buddha Nagar	9.2	8.4
Bulandshahr	14.6	8.9
Aligarh	11.5	6.0
Mahamaya Nagar	17.6	3.6
Mathura	14.0	3.1
Agra	12.1	2.5
Firozabad	13.2	4.6
Mainpuri	10.1	5.1
Bareilly	9.2	4.9
Pilibhit	9.1	6.2
Shahjahanpur	10.5	4.2
Kheri	15.2	4.8
Sitapur	11.9	2.8
Hardoi	13.0	5.0
Unnao	12.5	4.2
Lucknow	11.8	8.7
Farrukhabad	8.0	2.9
Kannauj	9.9	3.2
Etawah	11.3	5.8
Auraiya	18.7	3.0
Kanpur Dehat	8.8	3.6
Kanpur Nagar	10.6	5.3
Jalaun	18.4	3.2
Jhansi	13.2	3.5
Lalitpur	15.2	3.0
Hamirpur	16.6	4.2
Mahoba	11.8	3.8
Banda	16.6	10.8
Chitrakoot	10.8	3.8
Fatehpur	10.4	3.0
Pratapgarh	12.4	9.8
Kaushambi	3.9	5.9
Allahabad	8.3	8.8
Bara Banki	13.1	4.7
Faizabad	7.0	11.5
Ambedkar Nagar	12.0	9.8
Bahraich	17.3	3.1
Shrawasti	11.9	4.2
Balrampur	18.0	4.2
Gonda	18.5	4.1
Siddharthnagar	16.9	5.9
Basti	20.7	6.2
Sant Kabir Nagar	19.6	4.7
Mahrajganj	16.1	6.5
Gorakhpur	14.8	9.1
Kushinagar	12.3	6.0
Deoria	16.7	7.1

District	Hypertension clustering	Diabetes clustering
Azamgarh	17.4	10.0
Mau	28.0	9.3
Ballia	16.8	9.8
Jaunpur	15.9	6.5
Ghazipur	13.6	7.5
Chandauli	13.5	6.3
Varanasi	24.4	8.2
Sant Ravidas Nagar (B	12.3	6.2
Mirzapur	17.9	4.6
Sonbhadra	13.9	4.9
Etah	11.6	3.4
Kanshiram Nagar	12.3	3.3
Pashchim Champaran	9.6	3.6
Purba Champaran	9.1	6.3
Sheohar	6.4	2.6
Sitamarhi	7.7	5.5
Madhubani	9.4	6.7
Supaul	4.9	5.9
Araria	6.8	8.3
Kishanganj	8.9	5.3
Purnia	10.2	9.0
Katihar	8.0	7.8
Madhepura	5.8	9.2
Saharsa	6.0	5.3
Darbhanga	10.1	7.1
Muzaffarpur	11.6	7.0
Gopalganj	13.6	5.6
Siwan	15.8	5.6
Saran	9.4	9.6
Vaishali	9.7	8.0
Samastipur	6.9	6.2
Begusarai	8.0	8.2
Khagaria	7.3	10.4
Bhagalpur	8.0	9.0
Banka	9.7	8.5
Munger	9.0	13.6
Lakhisarai	6.2	8.5
Sheikhpura	9.3	4.9
Nalanda	7.0	5.5
Patna	8.0	11.5
Bhojpur	8.1	11.8
Buxar	8.1	7.7
Kaimur (Bhabua)	7.8	4.1
Rohtas	9.9	6.8
Aurangabad	9.9	7.4
Gaya	10.8	4.7
Nawada	9.4	4.6
Jamui	5.9	5.5
Jehanabad	5.7	8.2
Arwal	7.6	7.5
North District	23.8	3.6
West District	34.1	6.0
South District	30.7	5.9
East District	12.8	5.6
Tawang	19.1	1.5
West Kameng	16.9	2.8
East Kameng	13.8	5.5
Papum Pare	13.1	2.5

District	Hypertension clustering	Diabetes clustering
Upper Subansiri	20.6	3.5
Upper Siang	19.0	2.7
Changlang	16.1	4.0
Lower Subansiri	20.7	5.7
Dibang Valley	27.2	3.4
Lower Dibang Valley	24.3	4.6
Anjaw	24.2	9.8
Mon	15.5	4.6
Mokokchung	15.8	3.4
Zunheboto	22.0	2.6
Wokha	12.2	5.4
Dimapur	10.8	7.3
Phek	19.4	4.8
Tuensang	14.9	2.6
Longleng	14.1	5.3
Kiphire	7.2	2.5
Kohima	20.5	3.0
Peren	12.0	3.8
Senapati	14.4	4.3
Tamenglong	14.9	5.5
Churachandpur	11.8	8.2
Bishnupur	18.3	8.2
Thoubal	20.3	5.0
Imphal West	23.5	11.4
Imphal East	19.8	9.1
Ukhrul	12.0	4.0
Chandel	13.8	4.3
Mamit	8.9	6.1
Kolasib	12.4	8.6
Aizawl	18.1	7.5
Champhai	8.6	5.8
Serchhip	6.6	8.7
Lunglei	10.1	9.1
Lawngtlai	8.4	6.2
Saiha	8.9	4.0
Dhalai	6.6	8.4
South Garo Hills	12.8	11.8
Ribhoi	8.0	3.5
East Khasi Hills	12.9	2.7
Kokrajhar	11.0	5.4
Goalpara	9.8	7.3
Barpeta	11.5	9.9
Morigaon	12.4	6.1
Lakhimpur	14.2	3.7
Dhemaji	10.5	4.1
Tinsukia	9.8	8.3
Dibrugarh	11.9	10.5
Golaghat	12.1	5.5
Dima Hasao	10.5	5.2
Cachar	8.6	8.3
Karimganj	11.0	10.2
Hailakandi	13.2	8.0
Bongaigaon	7.4	8.3
Chirang	15.8	5.4
Kamrup	11.6	10.8
Kamrup Metropolitan	9.3	11.0
Nalbari	13.1	10.6
Baksa	18.6	9.3

District	Hypertension clustering	Diabetes clustering
Darrang	7.1	7.4
Udalguri	11.6	8.7
Darjiling	23.9	9.0
Jalpaiguri	15.5	10.0
Koch Bihar	13.1	7.6
Uttar Dinajpur	11.1	10.9
Dakshin Dinajpur	9.2	13.5
Maldah	10.2	10.5
Murshidabad	9.5	11.7
Birbhum	8.5	12.6
Nadia	9.6	13.0
North Twenty Four Par	12.0	14.4
Hugli	16.9	12.6
Bankura	13.1	11.2
Puruliya	10.5	10.3
Haora	17.5	12.9
Kolkata	14.8	14.2
South Twenty Four Par	13.3	12.7
Paschim Medinipur	10.9	11.9
Purba Medinipur	9.8	12.7
Garhwa	10.8	6.5
Chatra	9.1	5.2
Kodarma	10.0	9.2
Giridih	12.9	7.1
Deoghar	9.1	5.8
Godda	9.9	6.7
Sahibganj	6.4	7.0
Pakur	8.6	6.2
Dhanbad	13.7	7.7
Bokaro	16.0	6.0
Lohardaga	13.0	3.7
Purbi Singhbhum	15.2	9.2
Palamu	13.7	4.9
Latehar	11.1	4.8
Hazaribagh	15.2	5.0
Ramgarh	15.4	4.3
Dumka	9.2	4.4
Jamtara	13.3	6.1
Ranchi	15.4	6.2
Khunti	8.0	6.4
Gumla	11.0	4.8
Simdega	16.6	4.1
Pashchimi Singhbhum	9.6	2.6
Saraikela-Kharsawan	10.6	7.7
Bargarh	15.0	8.9
Jharsuguda	13.6	9.0
Sambalpur	14.2	7.0
Debagarh	12.1	4.1
Sundargarh	13.7	5.7
Kendujhar	12.2	5.5
Mayurbhanj	16.3	4.3
Baleshwar	13.5	5.7
Bhadrak	13.5	8.7
Kendrapara	11.3	7.6
Jagatsinghapur	18.2	10.1
Cuttack	15.1	10.1
Jajapur	16.9	8.3
Dhenkanal	13.6	6.1

District	Hypertension clustering	Diabetes clustering
Anugul	12.0	8.6
Nayagarh	12.1	13.0
Khordha	13.3	13.6
Puri	13.2	14.0
Ganjam	16.3	9.0
Gajapati	11.4	4.3
Kandhamal	16.5	6.1
Baudh	14.4	5.7
Subarnapur	14.5	6.4
Balangir	14.3	7.5
Nuapada	14.6	4.9
Kalahandi	21.2	7.6
Rayagada	11.4	6.3
Nabarangapur	12.6	3.3
Koraput	13.0	4.2
Malkangiri	9.9	6.7
Koriya	17.6	6.3
Jashpur	21.9	3.4
Raigarh	22.4	4.9
Korba	19.5	4.2
Janjgir - Champa	18.5	5.3
Kabeerdham	19.6	4.9
Rajnandgaon	21.5	3.9
Mahasamund	13.0	3.8
Dhamtari	16.7	6.8
Uttar Bastar Kanker	22.7	2.4
Narayanpur	13.5	4.4
Bijapur	10.8	3.7
Sheopur	13.8	5.1
Morena	9.1	7.5
Bhind	7.9	6.7
Gwalior	13.3	6.0
Datia	10.8	7.7
Shivpuri	5.9	4.7
Tikamgarh	4.7	5.6
Chhatarpur	9.6	5.6
Panna	6.6	3.7
Sagar	18.0	2.4
Damoh	12.4	3.4
Satna	8.9	6.1
Rewa	9.3	6.6
Umaria	12.9	5.7
Neemuch	22.9	4.8
Mandsaur	26.1	5.3
Ratlam	20.2	4.5
Ujjain	19.3	4.7
Dewas	22.1	4.3
Dhar	15.7	8.1
Indore	15.2	6.2
Khargone (West Nimar)	19.7	6.3
Barwani	17.9	5.6
Rajgarh	19.7	4.0
Vidisha	9.7	5.7
Bhopal	10.8	6.2
Sehore	21.6	4.4
Raisen	12.6	4.0
Betul	12.0	6.7
Harda	18.3	4.8

District	Hypertension clustering	Diabetes clustering
Hoshangabad	17.7	3.3
Katni	11.6	5.0
Jabalpur	9.8	9.2
Narsimhapur	16.0	6.9
Dindori	20.1	3.8
Mandla	17.3	4.2
Chhindwara	13.5	5.6
Seoni	12.7	6.3
Balaghat	14.7	5.0
Guna	12.5	5.7
Ashoknagar	10.0	5.2
Shahdol	11.3	5.1
Anuppur	16.8	6.8
Sidhi	12.6	4.7
Singrauli	12.1	4.5
Jhabua	14.7	4.8
Alirajpur	18.6	4.0
Khandwa (East Nimar)	11.8	3.4
Burhanpur	8.5	4.0
Kachchh	12.9	7.1
Banas Kantha	9.2	10.0
Patan	9.4	12.8
Mahesana	19.2	14.7
Gandhinagar	20.1	13.0
Porbandar	9.9	12.1
Amreli	8.6	10.6
Anand	21.5	12.0
Dohad	13.5	7.1
Narmada	14.8	7.8
Bharuch	17.3	13.8
The Dangs	14.3	2.9
Navsari	17.9	11.6
Valsad	20.8	11.2
Surat	16.2	10.5
Tapi	22.2	12.3
Diu	10.0	10.0
Daman	8.6	6.7
Dadra & Nagar Haveli	7.0	7.7
Nandurbar	19.2	6.2
Dhule	16.3	9.0
Jalgaon	16.8	7.8
Buldana	14.5	5.3
Akola	15.0	6.2
Washim	17.2	5.6
Amravati	14.3	7.7
Wardha	8.5	3.6
Nagpur	14.2	7.0
Bhandara	13.4	5.0
Gondiya	13.1	3.7
Gadchiroli	10.8	4.4
Chandrapur	12.5	4.9
Yavatmal	10.5	4.5
Nanded	12.0	5.6
Hingoli	13.1	6.2
Parbhani	11.2	4.1
Jalna	14.2	6.3
Aurangabad	14.4	9.1
Nashik	19.8	6.5

District	Hypertension clustering	Diabetes clustering
Mumbai Suburban	12.5	9.9
Mumbai	12.1	10.6
Raigarh	16.9	5.3
Pune	18.3	7.4
Ahmadnagar	19.2	6.5
Bid	21.1	5.9
Latur	14.5	5.2
Osmanabad	19.7	5.0
Solapur	19.9	6.1
Satara	24.6	6.8
Ratnagiri	27.7	9.7
Sindhudurg	28.4	14.3
Kolhapur	28.1	8.6
Sangli	27.0	11.1
Srikakulam	10.8	8.6
Vizianagaram	13.7	6.0
Visakhapatnam	14.9	8.6
East Godavari	17.1	12.0
West Godavari	17.9	11.0
Krishna	14.0	13.4
Guntur	15.9	14.0
Prakasam	15.8	14.2
Sri Potti Sriramulu N	14.3	12.4
Y.S.R.	16.7	11.8
Kurnool	19.6	10.1
Anantapur	14.5	6.3
Chittoor	13.3	9.9
Belgaum	16.1	7.9
Bagalkot	16.5	7.3
Bijapur	13.9	8.1
Bidar	16.7	5.6
Raichur	13.3	5.6
Koppal	13.2	6.1
Gadag	17.4	6.9
Dharwad	18.9	8.1
Uttara Kannada	20.3	7.6
Haveri	16.9	8.9
Bellary	16.0	5.3
Chitradurga	22.7	8.4
Davanagere	17.7	10.1
Shimoga	21.8	10.9
Udupi	27.6	11.3
Chikmagalur	19.2	7.8
Tumkur	19.8	9.8
Bangalore	19.2	10.3
Mandya	18.1	8.1
Hassan	21.9	9.5
Dakshina Kannada	23.9	7.7
Kodagu	21.8	9.1
Mysore	17.2	6.6
Chamarajanagar	22.6	7.5
Gulbarga	16.5	8.6
Yadgir	13.1	6.3
Kolar	20.2	8.7
Chikkaballapura	17.6	6.1
Bangalore Rural	21.5	9.6
Ramanagara	17.3	9.8
North Goa	19.7	13.8

District	Hypertension clustering	Diabetes clustering
South Goa	18.5	15.2
Lakshadweep	21.7	16.4
Kasaragod	16.2	11.5
Kannur	24.3	15.3
Wayanad	17.0	7.9
Kozhikode	19.4	15.0
Malappuram	17.5	13.9
Palakkad	25.5	16.2
Thrissur	20.6	17.2
Ernakulam	21.1	16.6
Idukki	23.2	13.6
Kottayam	25.2	17.2
Alappuzha	25.5	16.2
Pathanamthitta	31.2	20.4
Kollam	21.1	17.7
Thiruvananthapuram	17.0	15.0
Thiruvallur	17.7	13.0
Chennai	19.4	14.0
Kancheepuram	17.9	13.6
Vellore	15.8	12.0
Tiruvannamalai	11.6	10.6
Viluppuram	10.9	8.3
Salem	16.3	9.7
Namakkal	13.3	9.0
Erode	17.6	8.7
The Nilgiris	22.4	7.6
Dindigul	21.4	14.4
Karur	11.9	12.4
Tiruchirappalli	11.9	14.8
Perambalur	8.2	8.7
Ariyalur	11.6	12.1
Cuddalore	12.3	12.3
Nagapattinam	16.1	9.5
Thiruvarur	14.9	15.8
Thanjavur	15.4	11.7
Pudukkottai	16.6	11.0
Sivaganga	14.5	12.9
Madurai	16.6	11.5
Theni	21.6	14.3
Virudhunagar	9.3	10.2
Ramanathapuram	15.0	9.4
Thoothukkudi	14.2	13.3
Tirunelveli	10.9	10.7
Kanniyakumari	14.6	15.0
Dharmapuri	15.6	7.6
Krishnagiri	13.6	6.5
Coimbatore	18.6	8.9
Tiruppur	14.5	9.5
Yanam	23.0	13.0
Puducherry	18.3	11.2
Mahe	33.6	25.0
Karaikal	12.6	12.3
Nicobars	30.5	7.4
North & Middle Andam	19.1	7.8
South Andaman	16.5	11.1
East Siang	26.2	5.9
Kra Daadi	14.4	1.4
Kurung Kumey	15.3	3.8

District	Hypertension clustering	Diabetes clustering
Lohit	15.3	4.2
Longding	17.2	8.8
Namsai	19.0	5.3
Siang	21.6	3.7
Tirap	15.3	3.0
West Siang	28.7	6.0
Biswanath	15.4	3.8
Charaideo	10.8	7.9
Dhubri	10.6	4.8
Hojai	15.2	7.6
Jorhat	16.9	10.2
Karbi Anglong	11.9	6.7
Majuli	15.5	6.0
Nagaon	9.9	12.5
Sivasagar	16.4	9.4
Sonitpur	15.6	4.8
South Salmara Mancach	9.1	5.7
West Karbi Anglong	10.6	5.0
Balod	20.2	4.3
Baloda Bazar	20.6	3.5
Balrampur	18.4	3.5
Bastar	13.0	3.7
Bemetara	23.3	4.4
Bilaspur	18.1	5.5
Dantewada	13.8	4.7
Durg	20.6	7.2
Gariyaband	16.8	3.9
Kodagaon	15.9	4.4
Mungeli	18.1	5.0
Raipur	14.1	3.8
Sukma	11.6	3.2
Surajpur	19.6	5.6
Surguja	21.7	4.6
Central	21.6	6.4
East	21.6	5.7
New Delhi	16.7	4.5
North	14.4	4.4
North East	24.2	6.5
North West	17.5	6.9
Shahdara	22.0	6.2
South	17.2	5.0
South East	18.3	4.6
South West	15.0	9.3
West	16.7	4.9
Ahmadabad	12.1	16.0
Aravali	16.1	9.3
Bhavnagar	12.6	10.2
Botad	7.8	11.0
Chhota Udaipur	13.4	7.8
Devbhumi Dwarka	13.7	10.2
Gir Somnath	9.6	11.0
Jamnagar	10.8	10.9
Junagadh	16.2	13.5
Kheda	18.1	13.2
Mahisagar	9.8	7.8
Morbi	14.1	16.8
Panch Mahals	21.5	12.1
Rajkot	11.1	11.0

District	Hypertension clustering	Diabetes clustering
Sabar Kantha	20.4	10.0
Surendranagar	10.1	11.7
Vadodara	18.5	11.8
Bhiwani	12.8	5.0
Charkhi Dadri	13.5	6.0
Agar Malwa	9.8	9.2
Shajapur	23.1	3.1
Palghar	17.0	7.2
Thane	16.4	7.6
East Garo Hills	13.3	9.9
East Jantia Hills	9.8	3.1
North Garo Hills	16.7	11.2
South West Garo Hills	11.6	11.1
South West Khasi Hill	10.9	2.2
West Garo Hills	14.0	9.3
West Jaintia Hills	8.6	3.1
West Khasi Hills	7.5	2.2
Fazilka	31.2	8.7
Firozpur	31.7	7.9
Gurdaspur	33.6	6.9
Pathankot	28.2	5.5
Adilabad	14.3	4.9
Bhadradri Kothagudem	19.0	8.7
Hyderabad	20.4	12.8
Jagitial	14.5	7.1
Jangoan	15.3	7.7
Jayashankar Bhupalapa	17.3	6.4
Jogulamba Gadwal	14.8	5.2
Kamareddy	16.5	7.1
Karimnagar	16.8	8.8
Khammam	17.3	9.0
Komaram Bheem Asifaba	13.7	4.1
Mahabubabad	13.3	6.5
Mahabubnagar	15.9	5.4
Mancherial	17.1	7.0
Medak	15.9	8.0
Medchal-Malkajgiri	16.6	6.9
Nagarkurnool	15.3	5.5
Nalgonda	10.6	7.3
Nirmal	13.5	5.4
Nizamabad	16.0	6.1
Peddapalli	18.3	6.4
Rajanna Sircilla	18.7	6.5
Ranga Reddy	22.7	9.2
Sangareddy	16.7	5.5
Siddipet	18.1	6.4
Suryapet	14.3	10.6
Vikarabad	16.8	5.7
Wanaparthy	13.8	8.3
Warangal Rural	16.5	8.1
Warangal Urban	18.1	9.7
Yadadri Bhuvanagiri	18.1	7.2
Gomati	10.2	7.8
Khowai	9.6	9.8
North Tripura	11.2	12.9
Sepahijala	9.9	9.9
South Tripura	12.2	10.1
Unakoti	11.5	10.0

District	Hypertension clustering	Diabetes clustering
West Tripura	15.5	9.4
Amethi	11.2	5.9
Budaun	6.6	5.5
Ghaziabad	12.7	10.7
Hapur	21.5	5.1
Moradabad	19.8	8.0
Muzaffarnagar	16.3	7.7
Rae Bareli	11.7	3.6
Sambhal	15.3	4.1
Shamli	21.2	6.3
Sultanpur	14.0	8.5
Paschim Barddhaman	13.3	15.2
Purba Barddhaman	10.7	12.1