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# Variation in Chronic Diseases Across Households, Communities, Districts, and States in India

Suyash Mishra, MPhil,[1] Jessica M. Perkins, PhD,[2,3] Pijush Kanti Khan, MPhil,[1] Rockli Kim, ScD,[4] Sanjay K. Mohanty, PhD,[1] S.V. Subramanian, PhD[4,5]

**Introduction:** Globally, chronic noncommunicable diseases are the leading cause of death and accounted for 6 million deaths in India in 2016. However, the extent to which variation in chronic disease can be attributed to different population levels in India is unknown, as is whether variation in individual-level factors explains outcome variation at different population levels.

**Methods:** Cross-sectional data from the District Level Household and Facility Survey 2012–2013 conducted across 21 states, 275 districts, 14,235 villages, 378,487 households, and 1,098,940 individuals aged ≥18 years in India were analyzed in 2018–2019. Multilevel logistic models were used to partition variation in outcomes and attribute it to individual, household, village, district and state population levels. Outcomes included experiencing respiratory, cardiovascular, musculoskeletal, or eye symptoms; reporting a positive diagnosis by a doctor for chronic heart disease, hypertension, diabetes, or vision problems; and objectively assessed real-time measures of hypertension and diabetes.

**Results:** For reported diagnosis of hypertension or diabetes, a much larger percentage of variation in these outcomes was attributed to differences among households as compared to differences among units within other population levels. However, for objectively measured hypertension and diabetes, variation in these outcomes was important at the village level, followed by variation at the household level. Wealth status was positively associated with respiratory and cardiovascular symptoms, as well as all reported diagnoses and real-time measurements except for vision problems. Inclusion of individual-level sociodemographic variables explained 0%–30% of variation attributed to the household level for most chronic disease symptoms and diagnoses, but almost none at the higher levels.

**Conclusions:** These findings imply that household- and village-level factors explain substantial variation in the prevalence of chronic disease symptoms and reported diagnoses in India.

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## INTRODUCTION

In 2016, noncommunicable diseases (NCDs) were the cause of 71% of deaths worldwide.[1,2] Additionally, 38% of these deaths occurred prematurely (i.e., among people aged 30–70 years), and 85% occurred in low- and middle-income countries.[1,2] These 41 million deaths are projected to increase to 52 million by 2030.[1]

In 2016, in India, 63% of all deaths were due to NCDs,[3] though the burden of cardiovascular disease, diabetes, cancer, and chronic respiratory disease exhibited large variation across states from 1990 to 2016.[4] Of the 6.0 million deaths due to NCDs in India in 2016, a total of 1.4 million were premature. The largest

From the [1]Department of Fertility Studies, International Institute for Population Sciences, Mumbai, India; [2]Department of Human and Organizational Development, Peabody College, Vanderbilt University, Nashville, Tennessee; [3]Vanderbilt Institute of Global Health, Vanderbilt University Medical Center, Nashville, Tennessee; [4]Harvard Center for Population and Development Studies, Cambridge, Massachusetts; and [5]Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, Massachusetts

Address correspondence to: Jessica M. Perkins, PhD, Department of Human and Organizational Development, Peabody College, Vanderbilt University, 230 Appleton Place, PMB90, Nashville TN 37203. E-mail: jessica.m.perkins@vanderbilt.edu.

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contributor to mortality was cardiovascular disease. It had increased by 34% since 1990 to account for 28% of deaths, though the prevalence was higher in states experiencing a more advanced epidemiologic transition level. Chronic respiratory disease caused 10.9% of deaths; cancer, 8.3%; and diabetes, 3.1%, though variation existed across states.[4–8] From 1990 to 2016, the share of cardiovascular disease and diabetes among total deaths increased by 13 percentage points each in India. Projections suggest that deaths associated with chronic diseases in India will account for three quarters of all deaths by 2030.[9]

During the last 2 decades, many studies have identified individual risk factors for chronic disease.[10–15] For example, age, sex, education, marital status, place of residence, and income have been associated with diabetes,[16,17] coronary heart disease,[18,19] hypertension,[17] and related disability[20] in India. However, most of these studies only assessed variation in the outcome attributed to the individual level. Thus, they did not account for the possibility that contextual factors at multiple population levels, such as the household, village, district, and state levels, may simultaneously impact variation in chronic disease. Furthermore, individual-level models do not account for potential clustering of chronic disease incidence within population levels that exists simply because of individual or household factor clustering within these levels.

Multilevel modeling, however, provides a statistical framework to assess health outcomes from a multilevel perspective[21,22] by partitioning total variance in an outcome to different population levels (e.g., household, community, district, and state). These models permit interaction between population levels and individual characteristics, and results indicate how much variation is attributable to different population levels.[23] With the advent of these models, public health research has become increasingly concerned with the impact of context on disease patterns as defined by various population levels.[21,24–28]

Many states in India are considered demographically advanced with increasing life expectancy while nearing replacement fertility level. Therefore, many states are at high risk for increasing numbers of adults with chronic disease. Furthermore, both older adults and NCDs are likely to be clustered at different population levels owing to shared risk factors at different population levels. For example, clustering of NCDs within households likely occurs because the onset of NCDs is at about age 40 years in India and elder parents (aged ≥60 years) often live with older children (aged ≥45 years) in the same household.[29–32] In addition, many NCDs are hereditary and thus are likely to be clustered within households as well as within villages if family members do not move far away.

Although some previous studies found variation in chronic disease prevalence by place in India,[33–36] they examined prevalence and variation at a single level (e.g., individual, household, or state) or did not report variation attributable to different population levels despite accounting for that possibility.[37] However, policymakers seeking to improve population health need to understand the extent to which variation in chronic disease is associated with contextual factors at population levels above the individual level, especially after accounting for individual-level factors.

Thus, this study aims to:

1. Describe the distribution of chronic disease symptoms and diagnoses across individual-level socioeconomic and demographic factors;
2. Assess the extent of variation in these outcomes attributable to 5 conceptualizations of population levels (i.e., individuals, households, villages, districts, and states); and
3. Quantify the extent to which the clustering of individual characteristics at each population level explains variation in outcomes attributable to each population level.

The goal is to understand the extent to which context at different population levels may influence chronic disease symptoms and outcomes across the general population of adults in India.

## METHODS

### Study Sample

Publicly available de-identified data from the fourth round of the District Level Household and Facility Survey (DLHS-4) of 21 states in India were used for this study.[38] The DLHS-4 was conducted by the International Institute for Population Sciences with financial support and study approval from the Ministry of Health and Family Welfare, Government of India, 2012–2013.[38] All procedures were conducted according to the guidelines outlined in the Declaration of Helsinki.

The DLHS-4 used a multistage stratified sampling design and provided reliable estimates for districts and states as well as for rural and urban areas of India. The primary sampling units (PSUs) were census villages for rural sectors and National Sample Survey Office urban frame survey blocks for urban areas. For rural areas within districts, a 2-stage sampling design was adopted for selecting normal PSUs. First, probability proportional to size sampling was used to select PSUs, and then households were selected using circular systematic sampling. A 3-stage sampling design was used for selecting large PSUs in rural areas; probability proportional to size sampling was followed by selection of 1 or 2 segments, and then households were selected by circular systematic sampling. For urban areas, a 2-stage stratified sampling design was used to select urban frame survey blocks at random in the first stage, and households were selected by circular systematic

sampling in the second stage. For simplicity, PSUs in both rural and urban areas are hereafter referred to as villages. Data were collected from 1,176,132 adults aged ≥18 years nested within 378,487 households within 14,325 villages within 275 districts within 21 states including 3 union territories. The final sample consisted of 1,098,940 adults after excluding 77,192 with missing data. The median age of the study population was 38 years. The average household size was 5.3 (SD=2.6) adults. Appendix Table 1, available online, presents the final count of respondents across all levels included in this study.

### Measures

Respondents were asked whether they had experienced any symptoms pertaining to illness lasting >1 month within the past 1 year related to the respiratory system, cardiovascular system, musculoskeletal system, or eye problems, separately. In addition, they were asked whether they had been diagnosed by a doctor as having chronic heart disease, hypertension, diabetes, and vision problems (glaucoma or cataracts), separately. Each outcome was coded as a binary variable. In addition, a binary variable representing experience with any of the 4 symptoms was created, as well as a binary variable representing a reported diagnosis of any of the 4 chronic diseases. DLHS-4 also collected data on fasting blood glucose and blood pressure to assess the real-time prevalence of diabetes and hypertension in this population. Respondents with a fasting blood glucose level of ≥126 mg/dL were considered diabetic. This cut off was based on prior studies.[39,40] Blood pressure was measured twice, and the systolic and diastolic readings were recorded. The average of both systolic and diastolic readings was taken to assess for hypertension. A respondent was considered hypertensive if the average systolic reading was >140 mmHg and the average diastolic reading was >90 mmHg. Thus, there were a total of 5 symptom variables, 5 reported diagnosis variables, and 2 objectively measured, real-time disease variables. The analytical sample sizes for real-time hypertension and diabetes data were 814,019 and 790,033 respondents, respectively, owing to missing real-time data.

Data on age, sex (female or male), marital status, sector (urban or rural), religion, social group, household size (adults only), education, and wealth quintile were also included. For marital status, respondents were labeled as never married, married, or widowed/divorced/separated. Religion was classified as Hindu, Muslim, Christian, Sikh, and others. Social group was categorized as scheduled tribe, scheduled caste, other backward classes, and other, where the former 3 populations are entitled to government benefits. Household size was categorized as <5 adults, 5−7 adults, and >7 adults. Education was represented as never attended school, up to primary schooling, upper primary schooling, secondary schooling, and graduate and above. A composite variable representing a wealth index was created separately for rural areas and urban areas based on 25 household asset variables using principal component analyses.[41,42] The wealth index was then categorized into quintiles.

### Statistical Analysis

Multilevel modeling was conducted to estimate the potential for population-level influences on outcome variables. To decompose variation in outcomes, 5-level random intercept logistic models were specified to estimate the probability of an individual *I* nested in household *j*, village *k*, district *l*, and state *m* reporting an outcome (i.e., $y_{ijklm}$=1 if experienced symptom, reported diagnosis, or had real-time disease [separately]; 0 otherwise). For each outcome, an initial model was adjusted only for age and sex to provide baseline estimates. All estimates were evaluated using an $\alpha$ level of $p<0.01$, which are the estimates discussed in the main text (some Appendix tables available online also indicate results with an $\alpha$ consideration of $p<0.05$). These results were then compared to estimates from a subsequent model adjusting for all individual factors. Changes in the proportion of variance attributable to each population level were calculated.

The general form of the estimation model was defined as:

$$Logit(\pi_{ijklm}) = \beta_0 + BX'_{ijklm} + (g_{0m} + f_{0lm} + v_{0klm} + u_{0jklm}).$$

In the fully adjusted model, the parameter $\beta_0$ represents the log odds of having the outcome for a person belonging to the reference category of all the adjusted categorical variables ($X'_{ijklm}$). The terms $g_{0m}$, $f_{0lm}$, $v_{0klm}$, and $u_{0jklm}$ are the residuals corresponding to state-, district-, village-, and household-level random effects, each assumed to be normally distributed with a mean of 0 and a variance of $\sigma^2_{g0}$, $\sigma^2_{f0}$, $\sigma^2_{v0}$, and $\sigma^2_{u0}$, respectively. In multilevel logistic models, the variance at the lowest level cannot be directly estimated. Hence, the individual-level variance was assumed to be a function of the binomial distribution and approximated as 3.29 according to latent variable approach.[43]

The variance partition coefficient for any level z was calculated as:

$$VPC_z = \sigma^2_z/(\sigma^2_{g0} + \sigma^2_{f0} + \sigma^2_{v0} + \sigma^2_{u0} + 3.29).$$

Lastly, the proportion of variance explained by adjusting for individual-level characteristics was computed for each level by subtracting the variance with more terms from the variance of the initial model and converting to a percentage. Any percentage <0% was converted to 0 to indicate that including further individual-level explanatory factors in the model did not reduce variation in the outcome attributable to that level. Stata, version 13.1 was used to conduct cross-tabulation, and MLwiN, version 2.36 was used to conduct multilevel analysis. Data were analyzed in 2018−2019.

## RESULTS

Less than 2% of respondents experienced each of the chronic disease symptoms (Table 1). The prevalence of reported diagnoses of chronic heart disease, hypertension, diabetes, and eye disease was 0.4%, 2.1%, 1.8%, and 0.2%, respectively. Real-time hypertension and diabetes were present among 29.2% and 22.4% of the total sample population, respectively.

Appendix Tables 2 and 4, available online, present the variance estimates from baseline models at the household, village, district, and state levels. Using these results, Figure 1 depicts the proportion of variation in each outcome that is attributable to each level. Across symptoms, 47.6%−64.5% of the total variation was attributable to the household level, 11.5%−15.6% was attributable to the village level, 1.7%−3.7% was attributable to the district level, and 2.0%−7.1% was attributable to the state

**Table 1.** Distribution of Chronic Disease-Related Outcomes Among Adults Across 21 States in India (*n*=1,098,940)

| | Experienced symptoms in past 1 month | | | | | Reported chronic disease diagnosis by professional | | | | | Objectively diagnosed chronic disease at time of survey | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sociodemographic and economic subgroups | Respiratory, % | Cardiovascular, % | Musculoskeletal, % | Eye, % | Any 4 symptoms, % | Chronic heart disease, % | Hypertension, % | Diabetes, % | Eye disease, % | Any 4 diagnoses, % | Hypertension, % | Diabetes, % |
| All | 1.2 | 1.1 | 1.6 | 0.4 | 4.2 | 0.4 | 2.1 | 1.8 | 0.2 | 4.5 | 29.2 | 22.4 |
| Sector | | | | | | | | | | | | |
| Rural | 1.2 | 0.9 | 1.7 | 0.4 | 4.3 | 0.4 | 1.7 | 1.2 | 0.2 | 3.5 | 28.2 | 21.3 |
| Urban | 1.3 | 1.3 | 1.4 | 0.3 | 4.1 | 0.5 | 2.7 | 2.6 | 0.2 | 6.0 | 30.9 | 24.1 |
| Sex | | | | | | | | | | | | |
| Male | 1.3 | 1.1 | 1.2 | 0.3 | 3.8 | 0.5 | 1.7 | 1.9 | 0.2 | 4.3 | 32.9 | 23.1 |
| Female | 1.2 | 1.1 | 2.0 | 0.4 | 4.6 | 0.4 | 2.5 | 1.7 | 0.2 | 4.8 | 26.3 | 21.8 |
| Age, years | | | | | | | | | | | | |
| <30 | 0.3 | 0.2 | 0.4 | 0.1 | 1.0 | 0.1 | 0.3 | 0.1 | 0.1 | 0.5 | 14.1 | 11.3 |
| 30–45 | 0.9 | 0.7 | 1.4 | 0.2 | 2.8 | 0.3 | 1.4 | 1.0 | 0.1 | 2.8 | 25.8 | 19.8 |
| 45–60 | 1.9 | 1.8 | 2.5 | 0.5 | 6.3 | 0.7 | 3.8 | 3.7 | 0.3 | 8.4 | 38.7 | 30.0 |
| 60–75 | 3.2 | 2.9 | 3.6 | 1.1 | 10.3 | 1.2 | 5.9 | 5.4 | 0.7 | 13.1 | 48.5 | 35.9 |
| >75 | 3.9 | 3.0 | 3.6 | 1.6 | 11.9 | 1.4 | 6.5 | 4.5 | 1.0 | 13.3 | 53.4 | 39.0 |
| Religion | | | | | | | | | | | | |
| Hindu | 1.2 | 1.1 | 1.7 | 0.4 | 4.4 | 0.4 | 2.2 | 1.9 | 0.2 | 4.7 | 28.3 | 22.3 |
| Muslim | 1.3 | 1.3 | 1.3 | 0.4 | 4.3 | 0.6 | 2.5 | 2.3 | 0.2 | 5.6 | 29.4 | 23.4 |
| Christian | 0.7 | 0.5 | 0.7 | 0.3 | 2.1 | 0.2 | 0.9 | 1.1 | 0.2 | 2.4 | 27.8 | 20.7 |
| Sikh | 1.8 | 1.9 | 2.1 | 0.3 | 6.2 | 0.7 | 3.2 | 2.3 | 0.1 | 6.2 | 39.9 | 25.8 |
| Others | 1.3 | 0.9 | 1.4 | 0.4 | 4.1 | 0.3 | 1.5 | 0.8 | 0.3 | 2.9 | 28.9 | 20.6 |
| Social group | | | | | | | | | | | | |
| Schedule caste | 1.3 | 1.0 | 1.8 | 0.4 | 4.4 | 0.4 | 1.7 | 1.4 | 0.2 | 3.7 | 27.6 | 21.3 |
| Schedule tribe | 0.8 | 0.5 | 1.0 | 0.4 | 2.6 | 0.2 | 0.8 | 0.5 | 0.2 | 1.7 | 27.4 | 19.4 |
| Other backward classes | 1.2 | 1.0 | 1.4 | 0.4 | 3.9 | 0.4 | 2.2 | 2.1 | 0.2 | 5.0 | 29.1 | 22.4 |
| General | 1.6 | 1.7 | 2.1 | 0.4 | 5.7 | 0.6 | 3.3 | 2.7 | 0.2 | 6.8 | 32.7 | 25.9 |
| Education | | | | | | | | | | | | |
| Never attended school | 1.8 | 1.3 | 2.9 | 0.7 | 6.6 | 0.5 | 2.8 | 1.8 | 0.4 | 5.5 | 33.8 | 24.9 |
| Up to primary | 1.5 | 1.4 | 1.7 | 0.4 | 4.8 | 0.5 | 2.6 | 2.1 | 0.2 | 5.5 | 30.0 | 23.8 |
| Upper primary | 1.1 | 0.9 | 1.2 | 0.3 | 3.4 | 0.4 | 1.9 | 1.7 | 0.1 | 4.2 | 26.9 | 21.7 |
| Secondary | 0.8 | 0.9 | 0.9 | 0.2 | 2.7 | 0.3 | 1.6 | 1.6 | 0.1 | 3.7 | 26.1 | 20.3 |
| Graduate and above | 0.8 | 0.8 | 0.6 | 0.2 | 2.3 | 0.3 | 1.6 | 1.8 | 0.1 | 3.6 | 26.2 | 19.4 |
| Marital status | | | | | | | | | | | | |
| Never married | 0.3 | 0.2 | 2.7 | 0.2 | 0.9 | 0.1 | 0.2 | 0.1 | 0.1 | 0.5 | 17.0 | 11.6 |
| Married | 1.3 | 1.1 | 1.7 | 0.4 | 4.4 | 0.4 | 2.2 | 2.0 | 0.2 | 4.8 | 29.9 | 23.5 |
| Widow/divorced/separated | 2.7 | 2.4 | 3.5 | 1.1 | 9.6 | 0.9 | 5.7 | 3.8 | 0.7 | 11.0 | 44.3 | 31.7 |

(*continued on next page*)

**Table 1.** Distribution of Chronic Disease-Related Outcomes Among Adults Across 21 States in India (*n*=1,098,940) (*continued*)

| Sociodemographic and economic subgroups | Experienced symptoms in past 1 month | | | | | Reported chronic disease diagnosis by professional | | | | | Objectively diagnosed chronic disease at time of survey | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Respiratory, % | Cardiovascular, % | Musculoskeletal, % | Eye, % | Any 4 symptoms, % | Chronic heart disease, % | Hypertension, % | Diabetes, % | Eye disease, % | Any 4 diagnoses, % | Hypertension, % | Diabetes, % |
| Household size (adults) | | | | | | | | | | | | |
| <5 | 1.3 | 1.1 | 1.6 | 0.4 | 4.3 | 0.4 | 2.3 | 2.0 | 0.2 | 4.9 | 31.1 | 22.9 |
| 5–7 | 1.2 | 1.1 | 1.6 | 0.4 | 4.3 | 0.4 | 2.1 | 1.7 | 0.2 | 4.4 | 27.9 | 22.0 |
| >7 | 1.1 | 1.0 | 1.5 | 0.3 | 3.9 | 0.4 | 1.8 | 1.4 | 0.2 | 3.8 | 27.0 | 21.8 |
| Wealth quintile | | | | | | | | | | | | |
| Poorest | 1.1 | 0.7 | 1.5 | 0.5 | 3.8 | 0.3 | 1.3 | 0.7 | 0.3 | 2.6 | 25.7 | 18.7 |
| Poorer | 1.1 | 0.8 | 1.4 | 0.4 | 3.7 | 0.3 | 1.5 | 1.2 | 0.2 | 3.2 | 26.9 | 19.6 |
| Middle | 1.1 | 1.0 | 1.5 | 0.3 | 3.9 | 0.4 | 1.9 | 1.6 | 0.2 | 4.1 | 28.7 | 21.5 |
| Richer | 1.3 | 1.2 | 1.6 | 0.3 | 4.4 | 0.4 | 2.5 | 2.2 | 0.2 | 5.3 | 30.9 | 23.9 |
| Richest | 1.5 | 1.6 | 1.9 | 0.3 | 5.3 | 0.6 | 3.3 | 3.3 | 0.1 | 7.3 | 34.1 | 27.4 |

level. Across reported diagnoses, 18.0%–72.5% of the total variation was attributable to the household level, 7.5%–12.8% was attributable to the village level, 1.6%–5.2% was attributable to the district level, and 3.0%–7.0% was attributable to the state level. For real-time diseases, 2.4%–4.9% of the total variation was attributable to the household level, 5.1%–5.7% was attributable to the village level, 2.0%–2.4% was attributable to the district level, and 1.9%–3.8% was attributable to the state level.

Table 2 and Appendix Table 6, available online, show adjusted associations between symptoms and individual-level factors. Respondents in urban areas were more likely to experience respiratory symptoms (AOR=1.12, 99% CI=1.04, 1.19) and cardiovascular symptoms (AOR=1.30, 99% CI=1.22, 1.37). Household wealth quintile was positively associated with respiratory and cardiovascular symptoms, but negatively associated with musculoskeletal and vision symptoms. Education was negatively associated with all symptoms.

Table 3 and Appendix Table 7, available online, show adjusted associations between individual-level factors and reported diagnoses and real-time outcomes. Several socioeconomic and demographic factors were associated with outcomes. For example, respondents in urban areas were more likely to report receiving each of the disease diagnoses except for vision problems, as well as having a real-time diagnosis of hypertension and diabetes. Greater household wealth was associated with greater risk for all reported and real-time diseases except for vision problems. Education exhibited mixed associations with the diagnosis and real-time outcomes.

Appendix Tables 3 and 5, available online, show the estimated mean variance in outcomes attributable to each population level according to the adjusted model. Appendix Figure 1, available online, presents the percentages of variation in chronic disease symptoms and diagnoses attributable to these levels that were explained by factors included in the adjusted model. Findings indicated that changes in attributions of outcome variance differed across population levels and depended on the outcome. Except for experiencing musculoskeletal symptoms and reported diagnosis of vision problems, no variation in any of the outcomes attributable to the village, district or state levels was explained by accounting for potential clustering of individual socioeconomic and demographic factors. The proportion of variation attributable to the household level that was explained by adjusting for these factors ranged from 0% to 30.1%. For example, no variation in real-time diabetes diagnosis at the household level was explained, whereas over 30% of variation in real-time hypertension at the household level was explained by covariate adjustment.

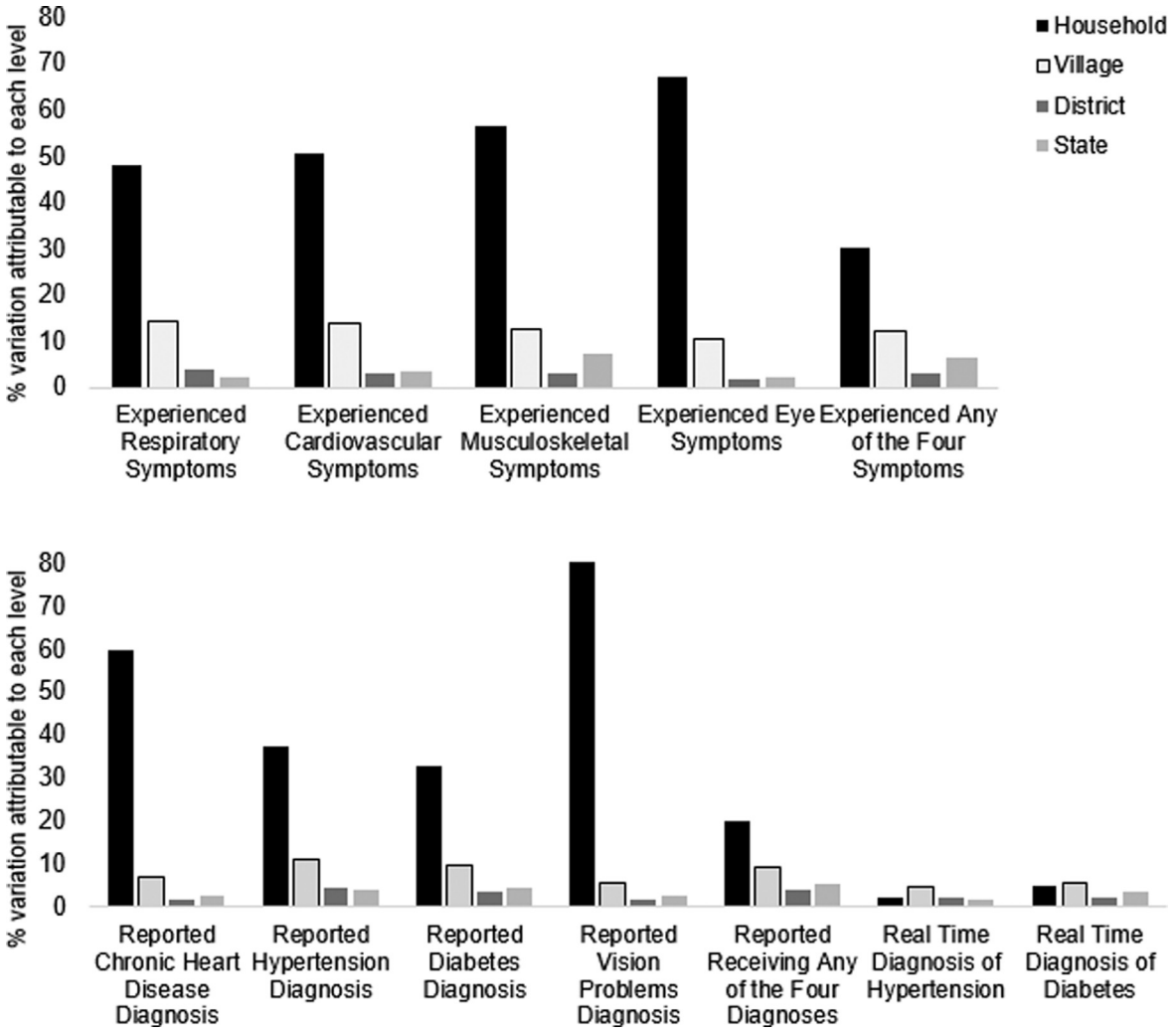


**Figure 1.** Percent of variation in chronic disease symptoms and diagnoses attributable to the household, district, village, and state levels in India according to data from the fourth round of the District Level Household and Facility Survey, 2012–2013 ($n$=1,098,940).

*Note*: These results are based on the baseline model only including age and sex.

## DISCUSSION

This paper describes the variation in chronic disease symptoms and diagnoses among adults in India attributable to 5 population levels: individuals, households, villages, districts, and states. This study has 3 salient findings. First, the percentage of variation in reporting a diagnosis of any chronic diseases included in this study was greatest between households and between villages compared with variation between districts and between states. Second, for reported diagnoses of hypertension or diabetes, a much larger percentage of variation was attributed to differences between households. However, findings from objective measurements of hypertension and diabetes at the time of the survey suggest slightly more variation attributed to the village level, followed by the household level.

Third, results indicate substantial clustering of individual-level sociodemographic characteristics within households. These factors explained 0%–30% of the variation in most outcomes initially attributable to the household level after they were added to the analytical model. By contrast, attribution of variation in outcomes to the village, district, and state levels was not reduced after adjusting for individual-level factors, except for experience of musculoskeletal symptoms and reported diagnosis of vision problems. In addition, socioeconomic factors appeared to be positively associated with respiratory and cardiovascular symptoms as well as chronic heart disease, hypertension, and diabetes. However, the reverse association with socioeconomic factors was found for musculoskeletal and eye symptoms, as well as for reported diagnosis of vision problems.

**Table 2.** AORs for Experiencing Chronic Disease Symptoms Among Adults in India in 2011–2012 ($n$=1,098,940)

| Explanatory factors | Respiratory symptoms AOR (99% CI) | Cardiovascular symptoms AOR (99% CI) | Musculoskeletal symptoms AOR (99% CI) | Eye symptoms AOR (99% CI) | Experiencing any of the 4 symptoms AOR (99% CI) |
|---|---|---|---|---|---|
| Sector | | | | | |
| Urban (vs rural) | **1.12 (1.04, 1.19)** | **1.30 (1.22, 1.37)** | 0.91 (0.81, 1.02) | 0.86 (0.73, 0.99) | **1.06 (1.00, 1.11)** |
| Wealth quintile | | | | | |
| Poorest | ref | ref | ref | ref | ref |
| Poorer | 1.04 (0.96, 1.12) | 1.15 (1.05, 1.25) | 0.95 (0.87, 1.03) | 0.80 (0.67, 0.93) | 1.00 (0.94, 1.05) |
| Middle | 1.05 (0.95, 1.15) | **1.28 (1.18, 1.39)** | 0.96 (0.86, 1.06) | 0.75 (0.59, 0.90) | 1.03 (0.97, 1.08) |
| Richer | **1.13 (1.02, 1.23)** | **1.46 (1.36, 1.57)** | 0.92 (0.82, 1.03) | 0.75 (0.59, 0.90) | **1.07 (1.01, 1.12)** |
| Richest | **1.14 (1.04, 1.24)** | **1.58 (1.46, 1.71)** | 0.87 (0.77, 0.97) | 0.69 (0.51, 0.87) | **1.06 (1.01, 1.11)** |
| Education | | | | | |
| Never attended school | ref | ref | ref | ref | ref |
| Up to primary | **1.11 (1.03, 1.18)** | 1.26 (0.67, 1.85) | 0.99 (0.91, 1.07) | 0.91 (0.79, 1.04) | **1.07 (1.03, 1.11)** |
| Upper primary | 0.98 (0.90, 1.06) | 1.07 (0.89, 1.25) | 0.90 (0.83, 0.98) | 0.90 (0.74, 1.05) | 0.95 (0.90, 1.00) |
| Secondary | **0.84 (0.76, 0.91)** | 1.03 (0.95, 1.11) | **0.72 (0.64, 0.80)** | 0.75 (0.59, 0.90) | **0.82 (0.77, 0.86)** |
| Graduate and above | **0.75 (0.62, 0.88)** | 0.9 (0.65, 1.16) | **0.55 (0.43, 0.68)** | 0.72 (0.49, 0.95) | **0.72 (0.65, 0.79)** |
| Social group | | | | | |
| Schedule caste | ref | ref | ref | ref | ref |
| Schedule tribe | 0.87 (0.74, 1.00) | 0.81 (0.66, 0.97) | 1.07 (0.94, 1.20) | 1.03 (0.82, 1.24) | 0.96 (0.88, 1.03) |
| Other backward classes | 0.98 (0.90, 1.06) | 0.98 (0.90, 1.06) | 0.96 (0.88, 1.04) | 1.02 (0.89, 1.15) | 0.97 (0.93, 1.02) |
| General | 0.94 (0.86, 1.02) | **1.19 (1.08, 1.29)** | 0.99 (0.89, 1.09) | 1.00 (0.85, 1.15) | 1.02 (0.97, 1.07) |
| Religion | | | | | |
| Hindu | ref | ref | ref | ref | ref |
| Muslim | **1.23 (1.10, 1.36)** | **1.27 (1.14, 1.40)** | 1.04 (0.91, 1.17) | 1.07 (0.87, 1.28) | **1.17 (1.10, 1.24)** |
| Christian | 1.11 (0.95, 1.26) | 1.08 (0.93, 1.24) | 1.03 (0.88, 1.19) | 1.00 (0.74, 1.26) | **1.09 (1.00, 1.18)** |
| Sikh | 1.01 (0.83, 1.19) | 1.03 (0.85, 1.21) | 1.19 (0.98, 1.39) | 0.93 (0.62, 1.24) | 1.07 (0.96, 1.18) |
| Others | 1.16 (0.98, 1.34) | 1.09 (0.89, 1.30) | 1.00 (0.82, 1.18) | 1.15 (0.87, 1.43) | 1.08 (0.97, 1.18) |
| Household size (adults) | | | | | |
| <5 | ref | ref | ref | ref | ref |
| 5–7 | **0.89 (0.84, 0.94)** | 0.94 (0.89, 0.99) | 0.89 (0.84, 0.94) | 0.88 (0.78, 0.98) | **0.89 (0.86, 0.93)** |
| >7 | **1.23 (1.13, 1.34)** | 0.90 (0.80, 1.01) | 0.83 (0.72, 0.93) | 0.86 (0.71, 1.02) | **0.83 (0.77, 0.88)** |
| Population level, VPC | | | | | |
| State | 2.0 | 3.3 | 7.5 | 2.2 | 6.3 |
| District | 3.7 | 2.9 | 3.1 | 1.6 | 3.1 |
| Village | 14.4 | 14 | 12.7 | 10.6 | 12.3 |
| Household | 48.2 | 50.4 | 56.6 | 67.2 | 30.1 |

*Note:* Boldface indicates statistical significance ($p$<0.01). Random intercepts 5-level logistic regression model adjusted regression model adjusted for all factors in the table as well as age, sex, and marital status.
VPC, variance partition coefficient.

One plausible explanation for substantial attributions of variation in chronic disease to the household level may be the clustering of shared genetic risk factors for chronic disease, as individuals having a family history of the disease are more likely to have similar disease risks. For example, with increases in longevity, there is likely to be clustering of related older adults in the households and they may all have similar genetic risks for chronic disease. In addition, consanguineous marriage practices (12% among ever married women) increase genetic similarity within households and thus may also increase household-level associated clustering of risk for chronic disease.[44] Furthermore, living in the same household may increase the clustering of risks owing to shared unhealthy lifestyle behaviors or experiencing the same environmental risks associated with the household context such as structure or location. Further research is needed, however, to assess the extent to which these potential explanations are warranted.

Results also found substantial variation in chronic disease symptoms and diagnoses attributable to the village level. Surroundings in which individuals live play a vital role in determining the disease pattern of that context,[25] but community-based models for prevention and control of chronic diseases are largely missing in India.

**Table 3.** AORs of Chronic Disease Diagnosis Among Adults in India in 2011–2012 ($n$=1,098,940)

| Explanatory factors | Reported chronic heart disease diagnosis AOR (99% CI) | Reported hypertension diagnosis AOR (99% CI) | Reported diabetes diagnosis AOR (99% CI) | Reported vision problems diagnosis AOR (99% CI) | Reported receiving any of the 4 diagnoses AOR (99% CI) | Real time diagnosis of hypertension AOR (99% CI) | Real time diagnosis of diabetes AOR (99% CI) |
|---|---|---|---|---|---|---|---|
| Sector | | | | | | | |
| Urban (vs rural) | 1.13 (1.02, 1.23) | **1.47 (1.40, 1.53)** | **1.85 (1.79, 1.92)** | 0.82 (0.64, 1.00) | **1.55 (1.50, 1.60)** | **1.23 (1.20, 1.26)** | **1.24 (1.22, 1.27)** |
| Wealth quintile | | | | | | | |
| Poorest | ref | ref | ref | ref | ref | ref | ref |
| Poorer | 1.01 (0.86, 1.16) | 1.13 (1.06, 1.21) | **1.42 (1.33, 1.51)** | 0.79 (0.59, 1.00) | **1.15 (1.10, 1.20)** | **1.07 (1.05, 1.09)** | **1.09 (1.06, 1.11)** |
| Middle | 1.16 (1.01, 1.32) | **1.29 (1.22, 1.38)** | **1.81 (1.72, 1.90)** | 0.80 (0.60, 1.01) | **1.36 (1.31, 1.41)** | **1.13 (1.11, 1.16)** | **1.16 (1.13, 1.18)** |
| Richer | 1.17 (1.02, 1.33) | **1.53 (1.45, 1.61)** | **2.29 (2.20, 2.38)** | 0.72 (0.49, 0.95) | **1.63 (1.58, 1.68)** | **1.22 (1.19, 1.24)** | **1.25 (1.22, 1.27)** |
| Richest | 1.28 (1.10, 1.46) | **1.68 (1.60, 1.77)** | **3.08 (2.98, 3.17)** | 0.75 (0.49, 1.01) | **1.97 (1.92, 2.03)** | **1.30 (1.27, 1.32)** | **1.37 (1.34, 1.39)** |
| Education | | | | | | | |
| Never attended school | ref | ref | ref | ref | ref | ref | ref |
| Up to primary | **1.26 (1.13, 1.39)** | **1.20 (1.14, 1.27)** | **1.25 (1.19, 1.32)** | 0.9 (0.72, 1.08) | **1.22 (1.17, 1.27)** | 1.02 (0.99, 1.04) | **1.04 (1.01, 1.06)** |
| Upper primary | **1.19 (1.03, 1.34)** | **2.20 (2.13, 2.28)** | **1.23 (1.15, 1.30)** | 0.96 (0.73, 1.19) | **1.14 (1.09, 1.19)** | 1.00 (0.98, 1.03) | 1.02 (0.99, 1.04) |
| Secondary | 0.95 (0.80, 1.11) | 1.02 (0.95, 1.09) | **1.22 (1.14, 1.29)** | 0.73 (0.50, 0.97) | **1.07 (1.02, 1.12)** | 0.99 (0.97, 1.01) | 1.00 (0.98, 1.02) |
| Graduate and above | 0.78 (0.57, 0.98) | 0.91 (0.82, 1.01) | 1.13 (1.04, 1.22) | 0.53 (0.17, 0.89) | 0.96 (0.91, 1.01) | **0.94 (0.92, 0.97)** | **0.94 (0.91, 0.96)** |
| Social group | | | | | | | |
| Schedule caste | ref | ref | ref | ref | ref | ref | ref |
| Schedule tribe | 0.80 (0.60, 1.01) | 0.83 (0.73, 0.94) | 0.77 (0.65, 0.88) | 1.15 (0.87, 1.43) | 0.85 (0.77, 0.93) | **1.05 (1.02, 1.08)** | 0.99 (0.96, 1.03) |
| Other backward classes | 1.06 (0.93, 1.19) | 1.10 (1.03, 1.17) | 1.06 (0.99, 1.13) | 1.00 (0.79, 1.21) | **1.08 (1.03, 1.13)** | **1.03 (1.01, 1.05)** | 1.02 (1.00, 1.04) |
| General | 1.11 (0.98, 1.23) | **1.21 (1.14, 1.29)** | 1.11 (1.04, 1.18) | 1.00 (0.77, 1.23) | **1.15 (1.10, 1.20)** | **1.03 (1.01, 1.05)** | 1.00 (0.98, 1.03) |

(*continued on next page*)

**Table 3.** AORs of Chronic Disease Diagnosis Among Adults in India in 2011–2012 (*n*=1,098,940) (*continued*)

| Explanatory factors | Reported chronic heart disease diagnosis AOR (99% CI) | Reported hypertension diagnosis AOR (99% CI) | Reported diabetes diagnosis AOR (99% CI) | Reported vision problems diagnosis AOR (99% CI) | Reported receiving any of the 4 diagnoses AOR (99% CI) | Real time diagnosis of hypertension AOR (99% CI) | Real time diagnosis of diabetes AOR (99% CI) |
|---|---|---|---|---|---|---|---|
| Religion | | | | | | | |
| Hindu | ref | ref | ref | ref | ref | ref | ref |
| Muslim | **1.43 (1.28, 1.59)** | **1.21 (1.12, 1.31)** | **1.24 (1.15, 1.34)** | 1.09 (0.79, 1.40) | **1.25 (1.19, 1.30)** | **1.09 (1.05, 1.12)** | **1.08 (1.05, 1.12)** |
| Christian | 1.05 (0.82, 1.28) | 1.00 (0.88, 1.14) | 1.09 (0.97, 1.22) | 1.32 (0.99, 1.66) | 1.09 (1.02, 1.17) | 0.98 (0.94, 1.01) | 1.04 (1.00, 1.09) |
| Sikh | 0.93 (0.67, 1.19) | 1.07 (0.93, 1.21) | 1.06 (0.93, 1.19) | 1.08 (0.62, 1.55) | 1.04 (0.94, 1.14) | **1.07 (1.03, 1.12)** | 1.02 (0.97, 1.08) |
| Others | 1.22 (0.96, 1.48) | 1.11 (0.96, 1.26) | 0.94 (0.78, 1.10) | 1.32 (0.94, 1.71) | 1.07 (0.97, 1.18) | 1.04 (1.00, 1.09) | 1.01 (0.96, 1.07) |
| Household size (adults) | | | | | | | |
| <5 | ref | ref | ref | ref | ref | ref | ref |
| 5–7 | 0.93 (0.83, 1.04) | 0.91 (0.86, 0.96) | 0.99 (0.94, 1.04) | 0.90 (0.74, 1.05) | **0.93 (0.91, 0.96)** | **0.94 (0.92, 0.95)** | 1.00 (0.98, 1.01) |
| >7 | 0.90 (0.74, 1.05) | 0.84 (0.77, 0.92) | 0.94 (0.86, 1.01) | 0.82 (0.59, 1.05) | **0.87 (0.82, 0.92)** | **0.92 (0.90, 0.95)** | 1.01 (0.98, 1.03) |
| Population level, VPC | | | | | | | |
| State | 2.6 | 4.2 | 4.4 | 2.6 | 5.4 | 1.5 | 3.7 |
| District | 1.9 | 4.5 | 3.5 | 1.6 | 4.1 | 2.3 | 2.0 |
| Village | 6.9 | 10.9 | 9.7 | 5.6 | 9.1 | 4.8 | 5.5 |
| Household | 59.6 | 37.4 | 32.7 | 80.4 | 20.0 | 2.4 | 4.8 |

*Note:* Boldface indicates statistical significance ($p<0.01$). Random intercepts 5-level logistic regression model adjusted regression model adjusted for all factors in the table as well as age, sex, and marital status.
VPC, variance partition coefficient.

Although prior multilevel analyses of poverty and health spending in India have reported the importance of the community level,[45,46] this study is the first to provide evidence on the simultaneous role of several population levels for chronic disease burden. Future research should explore contextual factors that may impact chronic disease symptoms, reported diagnoses, and real-time prevalence in India, for example, quality of healthcare infrastructure, distance from health centers, and social and physical environment.

### Limitations

Interpretation of the findings is subject to limitations. First, data are only from 21 states, representing 44% of the total population according to the 2011 census. Thus, results cannot be generalized to all states. Second, aside from the 2 objectively measured outcomes, data are self-reported and are therefore subject to the limitations inherent to all studies based on self-report data. Respondents may not be aware of experiencing symptoms and therefore not seek care or diagnoses. Third, the data are cross-sectional and therefore limit causal inferences. Lastly, data on relationships between household members and family history of chronic diseases may help explain outcome clustering at the household level, but such information was not available.

## CONCLUSIONS

Determining the relative importance of a population level for a chronic disease symptom or diagnosis is highly dependent on the population levels simultaneously considered and on the outcome of interest. By focusing only on one population level and ignoring others, little useful quantification of variation attributable to a given level can be obtained. This study validates that household- and village-level factors are both important in potentially influencing chronic disease prevalence in India. Therefore, public health researchers should account for multilevel influences in their models and scrutinize both micro- and macro-level factors in assessing chronic disease etiology.

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