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Markers and Drivers

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RAND LABOR AND POPULATION

Markers and Drivers: Cardiovascular Health of Middle-Age and Older Indians

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Abstract

Using the 2010 pilot study of the Longitudinal Aging Study in India (LASI), we examine the socioeconomic and behavioral risk factors for poor cardiovascular health among middle-aged and older Indians, focusing on self-reported and directly measured hypertension. The LASI pilot survey (N=1,683) was fielded in four states: Karnataka, Kerala, Punjab, and Rajasthan. These four states were chosen to capture regional variations and socioeconomic and cultural differences. We find significant inter-state differences across multiple measures of cardiac health and risk factors for hypertension, including body mass index, waist-to-hip ratio, and health behaviors. In contrast to the findings from developed countries, we find education and other markers of higher socioeconomic status (SES) to be positively associated with hypertension. Among the hypertensive, however, we find that those at higher SES are less likely to be undiagnosed and more likely to be in better control of their blood pressure than respondents with low SES. We also find significant inter-state variations in hypertension prevalence, diagnosis, and management that remain even after accounting for socio economic differences, obesity, and health behaviors. We conclude by discussing these findings and their implications for public health and economic development in India and the developing country context more generally.

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Introduction

With a population of over 1.2 billion (GOI, 2011), India is the second most populous country in the world. In the past decade, the country has witnessed accelerated economic growth, emerging as the world's fourth largest economy in purchasing power parity terms (World Bank, 2010). Together with economic development, the country is undergoing a demographic transition: the population is aging rapidly. Currently, the 65+ population in India is roughly 60 million people, accounting for 5% of the population (UNPD, 2009). By 2050, the 65+ population is projected to climb to over 13%, or approximately 227 million people. Economic development and population aging have contributed to an emerging non-communicable diseases trend, such as cardiovascular diseases and obesity, previously thought to be a concern mostly for affluent or developed countries (Mahal et al, 2009). According to the World Health Organization (WHO, 2009), age-standardized cardiovascular disease mortality among adults 60 years old or older was 1,978 per 100,000 persons in India, compared to 800 per 100,000 in the United States.

Researchers have documented a strong inverse relation between health and socioeconomic status (SES) in developed countries, such as the United States (Banks et al., 2006; Smith, 2004). However, this relationship is not well established in developing countries like India (Zimmer & Amornsirisomboon, 2001). Further, recent literature suggests that the direction of association between cardiac health and socioeconomic status in such developing countries may be opposite of what is observed in the developed world; that is, higher SES is associated with increased risk of poor cardiac health (Reddy, 2002; Reddy et al., 2007). As regional and national economies in India continue to expand, the consumption basket of many individuals is changing, leading to dietary changes and increased obesity that pose risks to cardiac health (Subramanian & Smith, 2006). This phenomenon has been documented in other developing countries, such as China, Brazil, and Russia, as well as South Asian countries like India, Sri Lanka, and Thailand (WHO, 2002; Monteiro et al, 2004).

From recently collected data in the Longitudinal Aging Study in India (LASI) pilot study, we examine SES gradients in cardiovascular health of older Indians across four states using both self-reports and health markers measured at the time of the interview. Self-reports of diagnosed medical conditions are tied to access to health care services, and therefore, can mask undiagnosed conditions (Smith, 2007; Lee & Smith, 2011), and in countries like India where access to health care is limited, the prevalence of undiagnosed condition is expected to greater than in developed countries. The use of biomarkers enables us to study health outcomes without self-report biases that may be differentially associated with SES and access to health services. These biomarker measures may also provide additional insights into true disease prevalence as well as the extent of un-diagnosis and good management of chronic diseases in India.

Methods

Data

The study sample is drawn from the pilot survey of the Longitudinal Aging Study in India. LASI is designed to be a panel survey representing persons at least 45 years of age in India and their spouses. The pilot study was fielded in four states: Karnataka, Kerala, Punjab, and Rajasthan. These four states were chosen to capture not only regional variations, but also socioeconomic and cultural differences. Punjab is an example of a relatively economically developed state located in the North, while Rajasthan, also in the north, is relatively poor. The southern state of Kerala, which is known for its relatively efficient health care system and high literacy rate (Shetty & Pakkala, 2010), is included as a harbinger of how other Indian states may develop. Karnataka, located in the south, is used as our reference state.

Data were collected from 1,683 individuals during October through December of 2010. Primary sampling units (PSUs) were stratified across urban and rural districts within each of the four states to capture a variety of socioeconomic conditions. LASI randomly sampled 1,546 households from these stratified PSUs, and among them, households with a member at least 45 years old were interviewed. The household response rate was 88.6%. All age-eligible household members and their spouses regardless of age were asked to be interviewed. The individual response rate was 91.7%, and the response rate for the biomarker component of the survey was 82.5%. We restrict the analysis in this paper to 1,451 respondents who are at least 45 years or age; spouses under age 45 are excluded.

Although the pilot round of LASI only surveyed four states, the overall demographic characteristics of our sample are congruent with the population characteristics of India. However, at the state level, a comparison of sample characteristics of respondents reveals a somewhat greater representation of uneducated individuals in Rajasthan and lesser representation of married individuals, women, and elderly in Karnataka (for more detail, see Arokiasamy et al. in this volume). While these differences may largely be due to the small sample size of the pilot study, the representatives of our findings should be interpreted with such caveats.

Measures

Hypertension: A binary variable indicating self-reported diagnosis of hypertension is created based on the following question: "Has any health professional ever told you that you have high blood pressure or hypertension?" As part of the biomarker module, LASI field investigators measured blood pressure, recording three readings each of systolic and diastolic, using an Omron 712c digital reader. We create a binary variable for measured hypertension based on the mean value of the second and third readings and classify respondents as hypertensive if they have systolic blood pressure of at least 140 mm Hg or diastolic blood pressure of at least 90 mm Hg. Because blood pressure tends to stabilize after sitting and resting, the first reading is excluded. For one respondent who had only two measurements for both systolic and diastolic pressure, we calculated the mean of these two readings. The comparison between diagnosed and measured hypertension is critical in differentiating those who are diagnosed and manage their blood pressure well from those who are diagnosed but fail to manage blood pressure, as well as differentiating undiagnosed from diagnosed among those who have high blood pressure readings.

Based on self-reported and measured hypertension, we define total hypertension as having ever been diagnosed by a health professional or hypertensive based on blood pressure readings at the time of the interview. Among the hypertensive (defined as total hypertension), we also define a measure of undiagnosed hypertension counting respondents who report not having ever been diagnosed with hypertension, but have high blood pressure based on the field measurements. We then defined a measure of good management of blood pressure to represent respondents who report having been diagnosed with hypertension, but manage to have low blood pressure based on the field measurements.

Obesity: The LASI biomarker module also included anthropometric measures, such as weight, height, and waist and hip circumferences. Based on these measures, we calculate body mass index (BMI) as weight in kilograms divided by height in meters squared and a waist-to-hip ratio (WHR). We create a categorical indicator for obesity if a respondent has a BMI of at least 30 kg/m^2, for overweight if BMI is between 25 and 29.9, and for underweight if BMI is less than 18.5.

Health behaviors: Smoking is constructed as a series of categorical variables for current smokers, former smokers, and those who have never smoked. Here, "smoking" refers to both cigarettes and any sort of chewing tobacco. Drinking is represented by a binary variable indicating whether or not the respondent currently drinks any alcohol. For vigorous physical activities[5], we construct a categorical variable that indicates the frequency of vigorous physical activities: everyday, sometimes (referring to more than once a week, once a week, or one to three times a month), and never or almost never.

LASI also asked whether or not a respondent has ever visited a private doctor with an MBBS degree (MBBS) in his/her lifetime. Respondents' self-report of diagnosis by a health professional is only possible given access to health services, which is often determined by socioeconomic standing rather than need. For example, those with higher SES have (better) access to health care and may also be more aware of or more likely to be diagnosed with cardiovascular diseases. We choose to control for having seen a private doctor with an MBBS degree as most respondents who self-reported being diagnosed with a condition reported being diagnosed by a private MBBS doctor. However, this variable provides only limited information about health care utilization, not being able to differentiate the extent of health care utilization or the use of different health care providers. While current paper is bound by data available from pilot survey, the baseline instrument of LASI will collect more detailed information about health care utilization, addressing this issue.

Socioeconomic status (SES): We use education, per capita household consumption, and caste affiliation as SES measures. In developed countries, education has been found to be the strongest measure of SES in relation to health (Smith, 2007), influencing it through multiple pathways, including health behaviors and access to health care (Lee, 2011). We categorize education into three groups: no schooling, primary or middle school education, and high school or more schooling based of respondent's self-reported highest level of attainment.

Caste is our second measure of socioeconomic standing. Respondents self-report as members of scheduled castes, scheduled tribes, other backward class, and all "others" including "no caste". Scheduled castes and scheduled tribes are particularly disadvantaged due to a historical legacy of inequality; scheduled tribes often represent more geographically isolated, ethnic minority populations while scheduled castes can generally be characterized as socially segregated by traditional Hindu society, often excluded from education, public spaces (wells for drinking water, temples, etc.), and most other aspects of civil life in India (Subramanian et al., 2008). Many of our respondents are considered by the Government of India to be a member of an OBC (other backwards class). While less marginalized and stigmatized than scheduled castes or tribes, these individuals also faced barriers to economic and educational opportunities (Subramanian et al, 2008). Even

[5] The question reads: "We would like to know the type and amount of physical activity involved in your daily life. How often do you take part in sports or activities that are vigorous, such as running or jogging, swimming, going to a health center or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads: everyday, more than once a week, once a week, one to three times a month, or hardly ever or never?"

though much has been done to improve the standing of scheduled tribes and scheduled castes, some of these efforts are relatively recent given the age of our respondents.

As a final measure of SES, we use per capita household consumption. This measure is preferred to income as past studies reveal that consumption is a better indicator of economic status in low-income and rural settings (Strauss et al., 2010). Consumption is measured at the household level, constructed from a sequence of questions that asks about expenses incurred over the previous year in the following categories: food (purchased, home-grown, and meals eaten out), household utilities (e.g. vehicle or home repairs, communications, fuel), fees (taxes, loan repayments, insurance premiums), purchases of durable goods (including clothing), education and health expenditures, discretionary spending items (alcohol and tobacco, entertainment, holiday celebrations and charitable donations), transit costs, and remittances. The household consumption burden is calculated according to the OECD equivalence scale that differentially weights household members: the household head (1), each additional adult (0.5), and each child (0.3). Total household yearly consumption is then divided by the OECD equivalent household consumption burden to obtain a per capita measure. LASI provides imputed data for missing values using a hot deck method, and we control for imputed consumption in the models to adjust for any systematic bias due to missing data for some components of household consumption. We operationalized this variable as dummy tertile indicators in our analysis. Consumption is more strongly correlated with education than caste. Individuals with at least a high school education have over two times greater per capita consumption than those without schooling: an average of 53,472 Rupees per capita for those with no schooling, 68,750 for those with primary or middle schooling, and 122, 058 for those with high school or more. The differences across castes are less pronounced. Members of scheduled castes and tribes consume less per capita (45,188 and 59,785, respectively) than those of other backwards classes and all others (81,403 and 73,800, respectively).

Demographics: We include categorical variables for age (45 – 54, 55 – 64, 65 – 74, and 75 or older) and a dummy indicator for gender.

Analysis

To account for sampling design and non-responses, means and percentages in the descriptive statistics are weighted with individual sample weights designed to be representative within each state. Additionally, we apply an all-state representative weight when pooling individuals across states to look at the sample as a whole. All analyses account for the clustered sample design, which was stratified on state, district, and urban-rural residency.

First, we examine inter-state differences in descriptive sample characteristics and socioeconomic status and report design-corrected Chi-square test (Stata Corporation, 2009).

Second, we examine inter-state variations in the prevalence of our cardiovascular health outcomes (i.e., self-reported, measured, total hypertension) and risk factors such as obesity and health behaviors; we again report the design corrected chi-square and F-statistics. We compare self-reported with measured hypertension and examine inter-state variations in undiagnosed and well managed blood pressure among the hypertensive (based on total hypertension).

Third, we test the bivariate association between our outcome of interest (i.e., self-reported, measured, and total hypertension as well as percent of undiagnosed and well managed among the hypertensive) and the demographic, geographic, and socioeconomic risk factors in a pooled sample accounting for stratified, cluster sample design.

We then estimate logistic multivariate models to investigate whether inter-state variations and SES gradients hold after accounting for other risk factors, such as obesity and health behaviors. We formally test changes in the odds ratios for inter-state and socioeconomic covariates after controlling for obesity and health behaviors. As all our dependent variables are binary variables, we run logistic models and report the odd ratios and confidence interval. Robust standard errors of the regression coefficients are computed to correct for heteroskedasticity.

Of particular interests are obesity and its relationship with socioeconomic status as it may explain the SES gradients in hypertension we observe. Thus, we estimate multinomial logistic models to estimate body mass index with normal weight as a reference category and ordinary least squares to estimate WHR. We investigate whether SES gradients and state variations in obesity hold after accounting for health behaviors. We formally test the difference in coefficients in states and SES and report F-statistics. All multivariate models are unweighted.

Results

Sample Characteristics: Table 1 shows the characteristics of our sample. Significant inter-state variations reflect patterns in economic development and population growth. While women's representation in the survey does not vary significantly across states, there is an uneven age distribution. Kerala and Rajasthan have greater proportions of elderly; about one third of the Kerala and Rajasthan population is 65 years old or above, compared to Karnataka and Punjab where

19% and 25% of respondents, respectively, are of the same age group. Most of our sample are members of an OBC or some "other/none" caste category. However, scheduled tribes and schedule castes are disproportionately represented across states: 35% of the Rajasthan sample identifies as a scheduled tribe, while the highest proportion of scheduled castes, 33%, is found in Punjab. Punjab also has the higher proportion of respondents who do not belong to a scheduled caste, tribe, or OBC.

The two northern states have relatively lower educational attainment – 79% of respondents in Rajasthan report having no schooling of any kind, nearly 60% in Punjab are similarly uneducated. In Kerala, much higher rates of educational attainment are observed – only 7% report receiving no schooling, and close to a third of the sample has received some high school education. These socioeconomic differences across states persist when we examine other measures of economic well-being, such as household per capita consumption. Karnataka has the highest amount of per-capita consumption, and Rajasthan has the lowest amount: 57% of respondents in Rajasthan fall into the bottom tertile of consumption compared to 18% of respondents in Karnataka and 24% in Punjab.

Inter-state Variations in Health Markers: Table 2 presents the distribution of self-reports of diagnosed, measured, and total hypertension across the four states. Prevalence of self–reports of diagnosed hypertension differs significantly across states. Kerala has the highest prevalence of self-reported diagnosed hypertension, while Rajasthan has the lowest (33% vs. 6%). Inter-state variations are also observed in measured blood pressure readings by the interviewer, but much more modestly, ranging from 35 and 36% in Kerala and Karnataka to 52.5% in Punjab. Once accounting for both self-reports of diagnosed hypertension and measured hypertension based on blood pressure readings, the inter-state variations in total hypertension is even more modest: the prevalence of total hypertension is the highest in Punjab (60%) and the lowest in Karnataka (42%).

Further investigation of those who are hypertensive illuminates inter-state variations in un-diagnosis and good management. Rajasthan has the highest prevalence of undiagnosed with 88% of hypertensive respondents never having received a diagnosis from a health professional, while Kerala has the lowest (37%). Differences in the percent of respondents who are successfully managing their hypertension follow the same geographic division: a third of the hypertensive in Kerala has successfully managed their blood pressure, while only 3% of the hypertensive in Rajasthan has managed their blood pressure well.

Significant inter-state variations are also observed for obesity measures, such as BMI and WHR. In Punjab, the percentage of the sample with BMIs over 30 (11%) is twice that of any other state. In Rajasthan, 41% of the elderly population is underweight (BMI under 18.5). In terms of WHR, less variation across states is observed, but differences still remain statistically significant: the lowest mean WHR is observed in Rajasthan for both men and women, and greater variance is observed in Karnataka for both men and women.

Health behaviors also differed significantly by states. The southern states of Karnataka and Kerala have notably higher percentages of smokers. Punjab has the lowest percentage of current smokers – only 5% report having used tobacco. The proportion of current drinkers is also low in northern states with just over 5% report drinking in Rajasthan. Vigorous physical activities are reported the least frequently by those residing in Punjab. There are significant state variations for health care utilization as well. Overall, 57% of respondents report having ever visited a doctor with an MBBS degree, which varies from 32% in Rajasthan to over 70% in Karnataka and Kerala.

SES gradients in Hypertension: In Table 3, we present SES gradients for self-reported diagnosis, measured, and total hypertension as well as un-diagnosed and good management among the hypertensive. We report sample design-corrected chi-square test statistics for SES gradients, as well as differences by gender and age.

We observe a significant and positive association between SES and self-reported hypertension diagnosis by a health professional: The prevalence is 7.7% among those with no education compared to 24.5% and 27.2% for those with primary/middle school education and the highest educated group, respectively. That is, more educated individuals are more likely to report having diagnosed hypertension. However, we do not see such significant education gradients in measured hypertension. Total hypertension, on the other hands, shows a significant difference in prevalence between those with and without formal schooling, but among those with schooling, no prevalence difference is found across different levels of educational attainment.

Among those with hypertension, more educated individual are also less likely to have undiagnosed hypertension and more likely to manage their hypertension under control. Among those with measured or self-reported hypertension and no schooling, 82% were undiagnosed compared to 48% among those with high school or more schooling. Similarly, respondents with hypertension and some high school education or more were almost three times more likely to manage their hypertension under control compared to those with no education.

Per capita household consumption reflects the socioeconomic gradient we see with education: the prevalence of self-reported hypertension among the lowest consumption tertile is almost 10% compared to 23% for the highest per capita consumption group. Similar to education, the association with measured hypertension does not follow that for self-reported; in fact, we do not find statistically significant bivariate associations between per capita consumption and measured and total hypertension. However, we find a very strong per capita consumption gradient in terms of the prevalence of undiagnosed hypertension and the proportion of good management. The undiagnosed prevalence rate is the highest among the low-consumption group (77%) and the lowest among the high-consumption group (52%). Consistent with the education gradients, we find that those at the highest consumption group are over twice as likely to manage their hypertension under control than those at the lowest consumption group.

Hypertension is also significantly associated with caste. Members of the “other” and “none” caste group have the highest prevalence of diagnosed hypertension followed by members of other backwards classes, whereas scheduled tribes and castes have the lowest. However, such differences between caste affiliations are no longer statistically significant for measured and total hypertension. Similar to education and per capita income, we observe significant differences by caste for undiagnosed and managed hypertension: over 90% of all scheduled tribe members were undiagnosed compared to just 54% among those with no scheduled caste or tribe affiliation. Schedule tribes and scheduled castes were also the least likely to be managing their hypertension under control; those respondents with no tribe or caste affiliation were over five times more likely than schedule tribes to be managing their blood pressure under control.

Finally, we note some gender and age differences in self-reports of diagnosed hypertension. The prevalence of self-reported diagnosed hypertension is significantly higher among women than men, while we find no significant gender differences in measured or total hypertension as well as undiagnosed and good management among the hypertensive. Our results also show the evidence of age gradients in the prevalence of hypertension but with different level of un-diagnosis. The youngest age group in our sample (ages 45 to 54) displaying the highest prevalence of undiagnosed hypertension, contributing to a steeper age gradients in the prevalence of diagnosed hypertension than that of total hypertension.

Do Inter-state variations and SES gradients in Diagnosed, Measured, and Total Hypertension Persist after controlling for Obesity and Health Behavior? Table 4 presents the results from three multivariate logistic regressions for our pooled sample: for self-reported, measured, and total hypertension. We estimate inter-state variations and SES gradients in these health outcomes, controlling for covariates, including age, gender, rural/urban residency, obesity measures (i.e., BMI and

WHR), and health behaviors. Logistic models are specified to estimate each of three dependent variables; odds ratios and 95% confidence intervals are presented.

We find that significant inter-state differences persist across each of the three models after controlling for all covariates and socioeconomic status. Respondents living in Punjab have two to three times the risk of hypertension than those residing in Karnataka across all measures of hypertension (self-reports, measured, and total). Respondents in Kerala, on the other hands, are 250% more likely to self-report hypertension, but no statistical difference was observed for measure and total hypertension. Respondents in Rajasthan, have increased odds of measured hypertension than respondents in Karnataka, while no significant difference is observed in self-reported hypertension.

We also find significant education gradients in all three measures of hypertension. Respondents who have completed some schooling are twice more likely to have hypertension than those without any schooling (total hypertension). It is also interesting to note that education gradients are more pronounced when we examined diagnosed hypertension than the prevalence based on measured or total hypertension. However, per capita consumption and caste are no longer significantly associated with hypertension once we control for other covariates.

In addition, and consistent with bivariate findings, we find significant gender difference in self-reports of hypertension diagnosis, but no gender difference in measured or total hypertension. We find significant age gradients across all measures, reflecting a well-documented association with cardiovascular health. We also find that overweight is a significant determinant of self-reported and total hypertension, but not statistically significant for measured hypertension. Smoking in the past is also found to be a significant risk factor for diagnosed hypertension, but not for measured or total hypertension. Although counter-intuitive, we find that physical exercise every day is positively associated with measured and total hypertension. Notably, we find significant associations between health care utilization (i.e., having ever visited a MBBS doctor) and having been diagnosed with hypertension: those who have ever visited a MBBS doctor are 1.6 times more likely to answer affirmatively than those who have never visited a MBBS doctor.

Do Obesity and Health Behaviors Explain Interstate Variations and SES gradients in Total Hypertension? We further investigate whether obesity and health behaviors may explain some of the interstate differences and the SES gradients in our measure of total hypertension, and the results are presented in Table 5. Obesity significantly reduced the inter-state variations, as well as the education gradients, though we stress that inter-state variations and SES gradients still persist after controlling for obesity. That is, obesity explains some of the inter-state variations and education gradients, but not all of the variances. Accounting for health behaviors, however, does not additionally reduce the socioeconomic gradient or geographic differences we observe.

SES gradients in Obesity We first present the bivariate association between SES and two obesity measures, BMI and WHR in Table 6. We observe significant association with each measure of SES: caste, education, and consumption for obesity. Scheduled tribes had the largest percentage underweight (54%), while respondents who were not a scheduled tribe caste had the highest prevalence of obesity at 7% for OBC and respondents with other or no caste. Additionally, about a quarter of other or no-caste respondents were overweight so that 35% of respondents in this group were overweight or obese. Education and per capita consumptions showed a similar gradient: those without education or in the bottom expenditure tertile had the highest percentage of respondents underweight (38-39%), while those with some high school education or in the top tertile for per capita consumption were about 32 to 38% overweight or obese. Across both men and women, we see smaller waist to hip ratios for consumption; but the association between waist to hip ratio and caste and education are only significant for men.

Do Inter-state variations and SES gradients in Obesity Persist after controlling for Health Behavior? Table 7 displays the results of our multinomial logistic regression for body mass index. We find persistent interstate variations in BMI even after controlling for other covariates. The residents of Punjab are less likely to be underweight and more likely to be overweight and obese than the residents of Karnataka. The residents of Kerala are less likely to be underweight than those in Karnataka but no more likely to be overweight or obese.

Similarly, we find that higher socioeconomic status as measured by education also increased the odds of being overweight or obese and decreased the odds of being underweight. Consumption also increased the odds of being obese and decreased the odds of being underweight, but did not show significant association with the odds of being overweight. Caste affiliation, another measured of socioeconomic status, also showed significant association with obesity. .

We also find that respondents ages 75 and over significantly increased the odds of being underweight compared to normal BMI. Women also increased the odds of being overweight and obese. Among health behaviors, currently smoking showed significant relationships with body mass index: current smoking increased the multinomial odds of being underweight and decreased the odds of being overweight compared to respondents in a healthy BMI range. Table 8 shows that health behaviors did not account for any interstate variations nor SES gradients.

Table 9 presents the results of OLS regression of WHR. Once we control for basic demographic characteristics, interstate variations and SES gradients in WHR are no longer statistically significant.

Discussion

Our analysis examines several markers and potential drivers of cardiovascular health of middle-aged and older adults in India using data from representative samples of four states: Karnataka, Kerala, Punjab, and Rajasthan. Using both self-reported and measured health outcomes, we find that there are significant socioeconomic and inter-state variations in the prevalence of hypertension, and notably such variations are more evident in self-reports of hypertension diagnosis than measured hypertension, suggesting self-report bias associated with the access to health care. Based on blood pressure readings, our estimate of hypertension prevalence of Indians aged 55 to 64 (43%) are comparable to those at the same age group in the United States (40%) and United Kingdom (39%) (Banks et al., 2006). Our results are in line with other previous studies in India. Gupta (2004) observes significant interstate variations, ranging from 4.5% in rural Haryana to 44-45% in urban Mumbai. Hypertension, accounting for both self-reported and directly assessed blood pressure readings taken during the interview, is estimated to affect 49% of Indians aged 45 and older and exhibits similar interstate variation, ranging from 42% in Karnataka to 60% in Punjab.

Changing lifestyle factors have been cited as a contributing cause of these trends. For example, obesity is particularly prevalent in Punjab than any other states. We found the supporting evidence that obesity explains some of the inter-state variations and SES gradients in hypertension prevalence, but obesity and health behavior do not account for all of the inter-state variations and SES gradients. After controlling for these lifestyle factors, we find that inter-state variations and SES gradients in hypertension persist. Identifying what contributes to such inter-state variations and SES gradients calls for further research.

The results of our analyses also suggest significant inter-state variations in diagnosis and management of such diseases and the role that the health care system plays. Respondents in Kerala had significantly lower likelihoods of undiagnosed hypertension than all other states. Coupled with the highest percentage of respondents having ever seen a licensed private doctor and a high proportion of respondents diagnosed with hypertension keeping their blood pressure under control, the development of the health infrastructure may play a critical role in shaping the course of disease management as such chronic conditions become more prevalent. In fact, having ever seen a licensed doctor was significantly related to self-reported diagnoses of hypertension.

We find significant SES gradients in hypertension—particularly with education--suggesting that those individuals with higher SES are at increased risk for hypertension when compared to those lower on the socioeconomic ladder. Education remains significant even after adjusting for obesity and health behaviors. Once we control for education, per capita household consumption and caste are no longer significantly associated with hypertension, suggesting that the historical disadvantages associated with caste membership as well as difference in consumption levels are predominantly mediated by education.

Our analyses also illustrate that individuals at the lowest SES are the most vulnerable to undiagnosed hypertension. This result is not surprising given that these individuals may also be less likely to be diagnosed due to more limited access to health care services. We also find that among those who are hypertensive, the more educated are more likely to keep their blood pressure under control. This finding is consistent with what has been found in other studies (Reddy et al. 2007).

The results of this study focus on the increasingly complex dynamic between health and its socioeconomic determinants, though it is not without limitations. Given the cross-sectional design of the LASI pilot survey, we cannot speak to causality of lower SES influencing health outcomes and highlight our findings only in the context of associations. Furthermore, due to small sample size, we cannot further examine SES gradients within states. We also do not have individual level consumption data and acknowledge the limitation of our health care utilization measure.

Conclusions and Implications

Our study contributes to a better understanding of the associations between higher socioeconomic status and increased risk of hypertension. Data from the pilot study of the Longitudinal Aging Study in India shows two-fold increases in the risk of these conditions for individuals of older ages, those who have higher education, and those who are overweight. Our comparison between self-reports and directly assessed measures of hypertension reiterates the significance of bias associated with self-reported medical conditions. The prevalence estimates based on doctor's diagnosis will seriously underestimate the true disease prevalence. As access to health care services increase, the prevalence of undiagnosed diseases will decline, but such decline will reach the socioeconomically disadvantaged group last. These findings are consistent with the interpretation that a rapid epidemiological transition in India is taking place due to changes in diet and lifestyle (Popkin et al. 2001; Yusuf et al 2001a) associated with economic development. Balancing economic growth with population health, perhaps through strengthening the healthcare system, should be considered in tandem to tackle the rapidly changing etiology of non-communicable disease in India.

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Table 1 Sample characteristics: Age 45 +

		unweighted N					weighted %						
		All states	karnataka	kerala	punjab	rajasthan	All states	karnataka	kerala	punjab	rajasthan	F-stat	
All		1451	315	413	365	358							
gender	men	706	150	184	188	184	48.69%	47.59%	44.87%	51.43%	51.46%	2.04	
	women	745	165	229	177	174	51.31%	52.41%	55.13%	48.57%	48.54%		
rural		1,040	206	289	259	286	72.91%	64.33%	75.26%	69.91%	80.77%	9.10	***
age	45 - 54	638	156	153	175	154	44.30%	49.46%	37.10%	48.06%	43.06%	2.29	*
	55 - 64	413	100	129	100	84	28.35%	31.77%	31.10%	27.38%	23.39%		
	65 - 74	256	44	81	53	78	17.84%	14.01%	19.51%	14.43%	21.77%		
	75+	144	15	50	37	42	9.51%	4.76%	12.29%	10.13%	11.78%		
caste	scheduled caste	242	53	31	123	35	14.49%	16.67%	7.04%	33.48%	9.85%	12.63	***
	scheduled tribe	152	27	0	0	125	13.87%	8.57%	0.00%	0.00%	35.40%		
	other backward class	510	188	177	43	102	39.29%	59.79%	42.93%	11.75%	28.32%		
	Other/none	546	47	205	199	95	32.34%	14.98%	50.04%	54.77%	26.43%		
education	no schooling	665	135	30	220	280	48.04%	42.59%	7.28%	60.12%	78.65%	37.02	***
	primary/ms schooling	513	123	249	97	44	34.06%	38.99%	61.13%	26.67%	12.18%		
	hs or more	272	57	133	48	34	17.90%	18.41%	31.59%	13.21%	9.17%		
per capita consumption (Rps)	median						41993	55250	42387	48093	28091		
	mean						55696	72431	58929	58934	35979		
	sd						45103	52510	45328	38811	28284		
	at bottom tercile	483	55	139	86	203	34.99%	17.92%	33.41%	23.58%	57.30%	7.35	***
	at middle	469	114	125	135	95	32.37%	37.30%	31.01%	36.97%	26.71%		
	at top tercile	480	136	143	144	57	32.64%	44.78%	35.58%	39.45%	15.99%		
	total	1432	305	407	365	355	100.00%	100.00%	100.00%	100.00%	100.00%		

* p<0.05; ** p<0.01; *** p<0.001

Notes: Consumption tercile calculated on an all-India basis. The cutoff for the middle tercile is 31672 India Rupees and the cut off for the top tercile is 57796 Indian Rupees. The cutoff values, means, medians, and standard deviations are reported with income top-coded at the 95% percentile after imputation.

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 2 Inter-state Variations in Health Markers

Health Markers		unweighted N					weighted %						
		all	karnataka	kerala	punjab	rajasthan	all	karnataka	kerala	punjab	rajasthan	F-stat	
Hypertension	Diagnosed	274	46	134	73	21	16.96%	14.66%	33.33%	20.03%	5.75%	16.66	***
	Measured	544	101	131	167	145	40.54%	35.64%	34.83%	52.50%	44.82%	5.50	**
	Total	661	118	201	192	150	48.51%	41.60%	53.66%	60.40%	46.46%	4.40	**
Among hypertensive	Undiagnosed	408	78	74	125	131	64.59%	66.14%	36.63%	65.03%	87.60%	17.43	***
	Good management	118	17	71	25	5	16.16%	14.34%	34.54%	13.07%	3.23%	13.44	***
Measured BMI	bmi < 18.5	304	84	50	38	132	26.74%	28.33%	13.42%	12.16%	41.08%	11.27	***
	18.5 ≤ bmi < 25.0	669	147	223	144	155	51.20%	50.02%	59.78%	46.11%	47.95%		
	25 ≤ bmi < 30	249	47	82	97	23	16.47%	16.13%	21.63%	31.16%	7.00%		
	30 ≤ bmi	82	16	20	33	13	5.59%	5.53%	5.18%	10.57%	3.96%		
Measured WHR	Mean for men						0.960	0.996	0.970	0.966	0.922	4.94	**
	Sd for men						0.145	0.200	0.079	0.111	0.121		
	Mean for women						0.925	0.921	0.957	0.945	0.897	4.78	**
	Sd for women						0.154	0.231	0.080	0.099	0.102		
	Non missing WHR	1282	281	361	300	340							
Self-reported smoking	current smoker	219	66	82	14	57	78.38%	20.84%	20.22%	3.85%	16.08%	11.39	***
	Former smoker	69	12	45	2	10	16.88%	3.79%	10.94%	0.54%	2.82%		
	never smoked	1158	237	283	349	289	4.74%	75.37%	68.83%	95.61%	81.09%		
Self-reported drinking	current drinker	135	33	50	33	19	9.12%	10.47%	12.32%	9.06%	5.43%	3.18	*
	not a drinker	1308	281	360	332	335	90.88%	89.53%	87.68%	90.94%	94.57%		
Self-reported vigorous physical activity	everyday	296	70	94	49	83	21.56%	22.17%	23.06%	13.34%	23.35%	2.86	**
	1+ per week	93	13	27	33	20	5.86%	4.07%	6.59%	9.09%	5.68%		
	once a week	59	7	13	32	7	3.26%	2.22%	3.23%	8.82%	1.94%		
	1 - 3per month	36	9	7	7	13	2.68%	2.86%	1.65%	1.89%	3.63%		
	hardly or never	962	216	269	244	233	66.63%	68.68%	65.47%	66.87%	65.39%		
health care utilization	Ever visited a MBBS	856	222	293	227	114	57.48%	70.45%	72.16%	62.15%	31.88%	22.17	***

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 3 % self-reported, measured, total, and undiagnosed hypertension, and % good management

		% self-reported			% measured			% total hypertension			% undiagnosed			% good management		
		All	F-stat		All	F-stat		All	F-stat		Hypertensive	F-stat		Hypertensive	F-stat	
N		1443			1309			1302			661			661		
All		16.96%			40.54%			48.51%			64.59%			16.16%		
gender	men	14.14%	6.82	*	40.44%	0.005		46.76%	1.23		67.36%	1.66		13.09%	4.35	*
	women	19.64%			40.63%			50.14%			62.19%			18.83%		
age	45 - 54	11.10%	4.66	**	33.80%	3.596	*	43.71%	5.22	**	72.12%	1.83		14.31%	0.31	
	55 - 64	19.52%			42.90%			51.01%			59.24%			15.89%		
	65 - 74	24.95%			49.71%			61.97%			59.68%			19.34%		
	75+	21.70%			48.26%			58.08%			64.27%			16.47%		
caste	scheduled caste	9.24%	9.76	***	34.40%	1.168		38.10%	1.99		74.99%	9.33	***	9.70%	6.11	**
	scheduled tribe	3.56%			47.17%			49.10%			92.12%			3.25%		
	OBC	19.28%			40.26%			49.09%			60.81%			17.42%		
	Other/none	23.40%			40.62%			52.23%			53.79%			22.35%		
education	no schooling	7.67%	30.63	***	38.18%	1.027		42.11%	5.11	**	82.03%	20.10	***	9.11%	8.38	***
	primary/ms	24.53%			44.41%			54.87%			54.32%			18.75%		
	hs or more	27.16%			39.42%			53.36%			48.25%			25.84%		
per capita consumption tertiles	low	10.06%	10.20	***	41.76%	2.497		46.88%	0.49		76.74%	8.29	***	10.49%	11.95	***
	mid	17.57%			44.88%			51.01%			64.27%			11.87%		
	high	22.87%			34.91%			47.12%			51.87%			25.62%		
State	Karnataka	14.66%	16.66	***	35.64%	5.499	**	41.60%	4.40	**	66.14%	17.43	**	14.34%	13.44	**
	Kerala	33.33%			34.83%			53.66%			36.63%			34.54%		
	Punjab	20.03%			52.50%			60.40%			65.03%			13.07%		
	Rajasthan	5.75%			44.82%			46.46%			87.60%			3.23%		

* p<0.05; ** p<0.01; *** p<0.001

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 4 Logistic regressions of self-reported, measure, and total hypertension

			self-reported				measured				total (self-reported or measured)			
			OR	CI		*	OR	CI			OR	CI		
Demo	Gender	female	1.773	1.071	2.935	*	1.154	0.868	1.535		1.320	0.944	1.846	
	Age	55 - 64	2.474	1.486	4.120	***	1.638	1.184	2.266	**	1.849	1.296	2.638	**
		65 - 74	3.534	2.332	5.357	***	2.028	1.363	3.018	***	2.977	1.913	4.633	***
		75+	3.254	1.531	6.915	**	2.284	1.303	4.002	**	2.740	1.571	4.780	***
	rural		0.998	0.641	1.553		1.022	0.730	1.432		0.956	0.681	1.343	
State	punjab		2.747	1.201	6.281	*	2.360	1.540	3.617	***	2.895	1.736	4.829	***
	rajasthan		0.681	0.304	1.526		1.849	1.007	3.392	*	1.716	0.987	2.985	
	Kerala		2.501	1.461	4.279	**	0.682	0.464	1.002		1.292	0.897	1.860	
Ses	Caste	scheduled caste	0.866	0.500	1.497		1.007	0.649	1.564		0.967	0.619	1.509	
		scheduled tribe	0.801	0.166	3.872		1.784	0.948	3.354		1.785	0.957	3.329	
		OBC	1.117	0.729	1.711		1.196	0.843	1.698		1.185	0.837	1.677	
	Education	primary/ms	2.232	1.282	3.885	**	2.326	1.542	3.508	***	1.985	1.307	3.014	**
		hs or more	3.135	1.856	5.294	***	1.966	1.090	3.546	*	2.132	1.233	3.687	**
	Consumption	Mid	1.360	0.849	2.177		1.320	0.902	1.933		1.313	0.899	1.916	
		High	1.534	0.858	2.745		0.722	0.496	1.050		0.955	0.655	1.393	
bmi	underweight	bmi<18.5	0.858	0.466	1.582		0.715	0.495	1.033		0.786	0.538	1.148	
	Overweight	25 ≤ bmi < 30	1.817	1.098	3.009	*	1.340	0.893	2.010		1.878	1.320	2.671	***
	obese	bmi ≥ 30.0	1.335	0.651	2.738		1.317	0.709	2.444		1.138	0.597	2.168	
	WHR		1.952	0.667	5.713		1.992	0.760	5.220		1.689	0.672	4.245	
Health Behaviors	Quit Smoking		2.006	1.215	3.312	**	0.718	0.344	1.499		0.768	0.444	1.328	
	Currently smoking		1.612	0.893	2.908		0.730	0.470	1.134		0.907	0.585	1.407	
	Currently drinks		0.923	0.491	1.737		1.329	0.780	2.263		1.152	0.742	1.787	
	Some exercise		0.883	0.482	1.615		1.142	0.752	1.735		0.968	0.617	1.517	
	Daily Exercise		0.866	0.481	1.561		1.458	1.037	2.050	*	1.464	1.008	2.127	*
	MBBS visit		1.691	1.122	2.550	*	1.016	0.770	1.339		1.191	0.909	1.561	
N			1251				1201				1198			
F-stat			6.64	***			3.11	**			3.95	**		

* p<0.05; ** p<0.01; *** p<0.001

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 5. Do Obesity and Health Behaviors Explain Interstate Variations and SES gradients in Total Hypertension? Results from Logistic regression models

			Model A		Model B		Model C		A vs. B		B vs. C
State	Punjab		3.082	***	2.670	***	2.895	***	4.74	**	1.59
	Rajasthan		1.511		1.519		1.716				
	Kerala		1.232		1.175		1.292				
SES	Caste	scheduled caste	0.882		0.936		0.967		2.38		0.13
		scheduled tribe	1.623		1.815		1.785				
		OBC	1.163		1.189		1.185				
	Education	primary/ms	2.196	***	2.080	**	1.985	**	4.72	*	1.98
		hs or more	2.234	**	1.978	**	2.132	**			
	Consumption	Mid	1.315		1.287		1.313		2.72		0.08
		High	1.039		0.950		0.955				

* p<0.05; ** p<0.01; *** p<0.001

Notes: Model A includes only covariates in the table, as well as rural, female and age. Model B includes all covariates of model A plus obesity measures; Model C includes all covariates in model B plus those for health behaviors. Table presents OR for the three models and the F-statistics when testing coefficients across models.

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 6 SES Gradients in Obesity

		BMI						WHR			
		% underweight	% Normal	% overweight	% obese	Chi-sq	*	Men	F-stat	Women	F-stat
N	1304	304	669	249	82			626		656	
All	100.00%	26.74%	51.20%	16.47%	5.59%			0.961		0.923	
caste	scheduled caste	30.67%	53.81%	10.22%	5.31%	8.67	***	0.964	4.34**	0.923	2.69
	scheduled tribe	53.56%	42.12%	3.58%	0.74%			0.905		0.887	
	OBC	23.49%	52.49%	17.51%	6.50%			0.981		0.931	
	Other/none	16.49%	52.67%	24.03%	6.82%			0.963		0.930	
education	no schooling	38.03%	49.19%	9.31%	3.47%	16.02	***	0.932	4.62*	0.914	1.37
	primary/ms	20.64%	52.57%	19.69%	7.10%			0.980		0.934	
	hs or more	8.27%	53.92%	29.43%	8.38%			0.982		0.935	
per capita consumption tertiles	low	38.54%	48.30%	11.19%	1.98%	10.84	***	0.939	3.46*	0.924	6.41**
	mid	26.76%	51.56%	14.63%	7.05%			0.957		0.902	
	high	13.65%	53.90%	24.66%	7.80%			0.989		0.948	

* p<0.05; ** p<0.01; *** p<0.001

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 7 Multinomial Logistic Regression Results of Obesity: BMI

Reference=normal			Underweight				Overweight				Obese			
			RRR	CI		*	RRR	CI			RRR	CI		
Demo	Gender	female	0.798	0.564	1.129		1.672	1.156	2.419	**	5.889	2.896	11.972	***
	Age	55 - 64	0.895	0.618	1.296		1.018	0.701	1.477		1.913	1.076	3.399	*
		65 - 74	1.307	0.855	1.997		0.960	0.609	1.514		2.226	1.132	4.379	*
		75+	2.100	1.271	3.472	**	0.756	0.397	1.439		0.396	0.088	1.785	
	rural		1.409	0.959	2.070		0.782	0.553	1.106		0.710	0.431	1.170	
State	punjab		0.439	0.260	0.742	**	2.678	1.627	4.407	***	4.234	1.800	9.963	**
	rajasthan		0.855	0.540	1.355		0.725	0.385	1.363		2.083	0.855	5.077	
	Kerala		0.420	0.258	0.686	**	0.915	0.561	1.493		0.669	0.309	1.446	
Ses	Caste	scheduled caste	1.221	0.757	1.969		0.550	0.331	0.913	*	0.895	0.389	2.058	
		scheduled tribe	1.816	1.060	3.111	*	0.496	0.176	1.392		0.000	0.000	0.000	***
		OBC	1.187	0.794	1.776		0.893	0.619	1.288		1.220	0.658	2.261	
	Education	primary/ms	0.935	0.618	1.413		1.999	1.285	3.110	**	3.137	1.585	6.208	**
		hs or more	0.456	0.243	0.857	*	2.532	1.506	4.259	***	3.266	1.506	7.084	**
	Consumption	Mid	0.797	0.557	1.140		1.005	0.651	1.550		2.442	1.145	5.211	*
		High	0.451	0.294	0.690	***	1.353	0.885	2.069		2.675	1.233	5.804	*
Health Behaviors	Quit Smoking		0.939	0.459	1.921		0.967	0.470	1.991		1.551	0.426	5.648	
	Currently smoking		1.710	1.104	2.649	*	0.494	0.257	0.950	*	0.635	0.206	1.951	
	Currently drinks		0.962	0.548	1.688		1.313	0.676	2.551		2.635	0.932	7.454	
	Some exercise		0.901	0.561	1.447		0.844	0.514	1.386		0.972	0.436	2.167	
	Daily Exercise		0.830	0.566	1.217		0.705	0.461	1.080		0.914	0.443	1.882	
	MBBS visit		0.741	0.530	1.036		1.052	0.748	1.480		0.844	0.491	1.449	
N			1278											
Wald chi2			7089.82	***										

* p<0.05; ** p<0.01; *** p<0.001

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 8 Do Health Behaviors Explain Interstate Variations and SES gradients in Obesity? Results from Multinomial Logistic Regression Models

		Model A (Demo)			Model B (Demo + health behavior)			Model A vs. B		
		Under-weight	Over-weight	Obese	Under-weight	Over-weight	Obese	Under-weight	Over-weight	Obese
Punjab		0.403 **	2.861 ***	4.359 ***	0.439 **	2.678 ***	4.234 **	2.41	3.73	0.45
Rajasthan		0.866	0.707	2.038	0.855	0.725	2.083			
Kerala		0.421 ***	0.863	0.676	0.420 **	0.915	0.669			
Caste	scheduled caste	1.219	0.534 *	0.890	1.221	0.550 *	0.895	1.00	5.93	2.02
	scheduled tribe	1.870 *	0.492	0.005 ***	1.816 *	0.496	0.006 ***			
	OBC	1.171	0.839	1.187	1.187	0.893	1.220			
Education	primary/ms	0.901	2.003 **	3.075 **	0.935	1.999 **	3.137 **	4.34	5.53	0.68
	hs or more	0.411 **	2.765 ***	3.291 **	0.456 *	2.532 ***	3.266 **			
Consumption	Mid	0.792	0.997	2.361 *	0.797	1.005	2.442 *	0.05	0.63	1.18
	High	0.451 **	1.369	2.630 *	0.451 ***	1.353	2.675 *			

* p<0.05; ** p<0.01; *** p<0.001

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)

Table 9 OLS Regression Results of WHR

			Estimates	SE	*
Demo	Gender	female	-0.032	0.009	**
	Age	55 - 64	0.001	0.012	
		65 - 74	0.002	0.012	
		75+	0.004	0.015	
	rural		0.000	0.012	
State	Punjab		-0.001	0.022	
	Rajasthan		-0.032	0.022	
	Kerala		0.001	0.019	
SES	Caste	scheduled caste	-0.004	0.014	
		scheduled tribe	-0.022	0.017	
		OBC	0.004	0.009	
	Education	primary/ms	0.004	0.012	
		hs or more	0.004	0.014	
	Consumption	Mid	-0.008	0.010	
		High	0.014	0.013	
Health Behaviors	Quit Smoking		-0.003	0.016	
	Currently smoking		-0.008	0.013	
	Currently drinks		0.032	0.014	*
	Some exercise		-0.022	0.011	*
	Daily Exercise		-0.016	0.011	
	MBBS visit		0.011	0.009	
N		1255			
F-stat		4.24	***		

* p<0.05; ** p<0.01; *** p<0.001

Source: Longitudinal Aging Study in India (LASI) Pilot Wave (2010)