



Association between socioeconomic status and diabetes in India

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Complete List of Authors:	Corsi, Daniel J; McMaster University, Population Health Research Institute Subramanian, S V; Harvard School of Public Health,
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3 **Title** Association between socioeconomic status and diabetes in India: a cross-sectional
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8 **Authors and affiliation**
9

10 Daniel J Corsi, MSc, Population Health Research Institute, McMaster University,
11
12 Hamilton, ON, Canada
13

14 SV Subramanian, PhD, Professor of Population Health and Geography,
15
16 Department of Society, Human Development, and Health, Harvard School of Public
17
18 Health, Boston, MA, USA
19
20
21

22 **Corresponding author details**
23

24 Professor S V Subramanian, Harvard School of Public Health, 677 Huntington Avenue,
25
26 Boston MA 02115, USA; Tel: 617-432-6299; Fax: 617-432-3123; Email:
27
28

29 svsubram@hsph.harvard.edu
30
31

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ABSTRACT

Objectives To quantify the association between socioeconomic status (SES) and type-2 diabetes in India

Design Nationally representative cross-sectional household survey

Setting Urban and rural areas across 29 states in India

Participants 168,135 survey respondents aged 18-49 y (women) and 18-54 y (men)

Primary outcome measure Self-reported diabetes status

Results Markers of SES were social caste, education, and household wealth. The overall prevalence of diabetes was 1.5%; this increased to 1.9% and 2.5% for those with the highest levels of education and household wealth, respectively. In adjusted multilevel logistic regression models, education (odds ratio 1.87 for higher education *vs* no education) and household wealth (odds ratio 4.04 for richest quintile *vs* poorest) were related to diabetes ($P < 0.0001$). In a fully adjusted model including all socioeconomic variables and body mass index (BMI), the odds ratio for diabetes was 2.58 (95% credible interval [CI]: 1.99, 3.40) for the richest quintile of household wealth versus the poorest.

Conclusions We found that the highest socioeconomic status groups in India appear to be at greatest risk for type-2 diabetes. This raises important policy implications for addressing the disease burdens among the poor versus those among the non poor in the context of India, where nearly half of the population is living in poverty.

ARTICLE SUMMARY

Article Focus

- The relationship between socioeconomic factors and type-2 diabetes has not been previously studied for the whole of India
- Our objective was to investigate associations between measures of socioeconomic status (defined as social caste, education, household wealth) and self-reported diabetes status in India
- In addition we explored geographic variation in diabetes between states and local areas in India

Key messages

- The highest socioeconomic groups appear to be at greatest risk for diabetes in India
- In addition, there is substantial geographic heterogeneity in the prevalence of diabetes
- These findings raise important policy implications for in addressing the disease burdens among the poor versus those among the non poor in the context of India, where nearly half of the population is living in poverty.

Strengths and Limitations

- The key strength of this study is the use of a large, nationally-representative survey to assess the socioeconomic and geographic patterning of diabetes across all of India. Limitations include the relatively younger age of the sample and assessment of diabetes status on the basis of self-reports.

INTRODUCTION

The prevalence of type-2 diabetes in India has been investigated in numerous population based surveys conducted across a range of settings since the 1970s.[1-6] Despite multiple prevalence studies, few studies have considered the association between socioeconomic status (SES) and type-2 diabetes in India. Recently, it has been suggested that “poor people are disproportionately affected” by diabetes and other non-communicable diseases in low and middle income countries [7], although the empirical evidence in the Indian context remains limited. Studies among populations from a few geographic regions in India have provided some evidence of a positive SES-diabetes association [6 8-9]; however the strength and consistency of this association across the whole of India remains uncertain.

Type-2 diabetes is the most common form of diabetes globally, accounting for greater than 85% of cases.[10] The incidence of type-2 diabetes is related to genetic and non-genetic components, with the latter being greatly influenced by modifiable risk factors such as obesity, diets low in fibre and high in trans fat, and physical inactivity.[11-12] These lifestyle behaviours themselves are strongly patterned by SES [13], and may be mediators on the causal pathway between SES and the onset of type-2 diabetes.[14] In high income countries, the SES-diabetes relationship appears to be negative, with the poor at greatest risk. For example, strong associations have been observed between poverty, low education and type-2 diabetes among African American women [15-16], and among White women and men in the United States.[17] Similarly, a study from Canada described an inversely graded SES-diabetes association with an odds ratio of 1.9 for men (95% CI: 1.6-2.4) and 2.8 (95% CI: 2.2-3.4) for women for the

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3 lowest versus highest income groups.[18] A recent meta-analysis of 23 epidemiological
4 studies and 43 measures of SES-diabetes association revealed an overall increased risk
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6 for type-2 diabetes for low SES groups based on education, occupation, and income.[19]
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10 The strength of the association, however, was less consistent in low and middle income
11 countries (LMICs), and few studies have been conducted in these countries.
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15 Concern has been raised over the anticipated rapid increase in type-2 diabetes
16 prevalence in India.[20-21] Evidence on the secular increases in diabetes prevalence in
17 India, however, have been limited to urban areas of Southern India[4 22-23], and have
18 focused on the mean rates of diabetes rather than how it is distributed in the population.
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20 In this paper we investigate the SES-diabetes relation in India using a large-scale
21 nationally representative survey. In addition, we investigate the geographical distribution
22 of diabetes at the state and local area levels in India.
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34 **METHODS**

35 **Data source**

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37 We use data from the 3rd National Family Health Survey (NFHS), conducted in 29
38 states in India between November 2005 and August 2006.[24] NFHS-3 is a major
39 national health survey in India which collected information on a range of indicators
40 including reproductive health, nutritional status of adults and children, utilization of
41 health care services, and blood testing for HIV prevalence. NFHS-3 covered all states in
42 India, which comprise nearly 99% of the population, but excluded Union Territories. The
43 survey was designed to provide estimates of key indicators (except HIV prevalence) for
44 each state by urban and rural areas.
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Survey design

A uniform multistage sampling strategy was adopted in all states, with separate sampling in urban and rural areas.[25-26] In rural areas, a two stage sample was carried out using a list of villages from the 2001 census as the sampling frame. In the first stage, a stratified sample of villages was drawn with probability proportional to the size of the village. In the second stage, a random selection of households was drawn in each village from a complete list of households compiled during field visits carried out in each sampled village. In urban areas, a similar procedure was implemented beginning with a stratified random sample of municipal wards based on the 2001 census. Next, one census enumeration block (150-200 households) was selected from within wards using probability proportional to size. Finally, as in rural areas, field enumerators undertook a household listing operation in selected blocks and a random sample of households was made. In both rural and urban areas, 30 households were targeted for selection in each of the sampled units. The overall household response rate for NFHS-3 was 98%.[24]

All ever-married and never-married women aged 15-49 in selected households were invited to participate in the survey. In 22 states, men aged 15-54 in a subsample of households were eligible for the men's survey. In the remaining seven states (Andhra Pradesh, Karnataka, Maharashtra, Manipur, Tamil Nadu, Uttar Pradesh, and Nagaland) all men were invited to participate. The additional men recruited in these states was for the purpose of HIV testing to provide reliable state level estimates of HIV prevalence in certain states. Interviews were conducted in 1 of the 18 Indian languages in the respondent's home and the response rates were 95% for women and 87% for men.[24] During interviews, the weights and heights of survey respondents were measured by

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3 trained field technicians using standardized measuring equipment designed for survey
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5 settings.[27]
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8 In total NFHS-3 collected information from 109,041 households, 124,385 women
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10 age 15-49, and 74,369 men age 15-54.[24] We restricted our analyses adults 18 years
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12 and older and non-pregnant women (n=171,207). Respondents who did not report or
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14 know their diabetes status (n= 2,385) or with incomplete information for any of the
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16 independent variables considered in the analysis (marital status, religion, caste, education,
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18 household wealth) were excluded (n=687). Analyses were conducted on a sample of
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20 168,135 respondents, (65,255 men and 102,880 women). Additional analyses
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22 considering body mass index (BMI) were restricted to a sample of 158,936 due to
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24 missing and/or implausible values for height and/or weight.
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29 **Outcome and independent variables**

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31 The primary outcome was diabetes, assessed on the basis of self-reports by survey
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33 respondents. Socioeconomic status was measured by social caste, education, and
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35 household wealth. Social caste was reported by the household head. The categories were
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37 Other Caste, Scheduled caste, Scheduled tribe, Other Backward Class, and No Caste.
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39 Other Caste is a heterogeneous group that is traditionally viewed as having higher social
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41 status. Scheduled castes and scheduled tribes are considered lower, socially
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43 marginalized groups in India.[28] Education was specified as no education, primary,
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45 secondary, or higher education. Household wealth was defined by an index based on
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47 indicators of asset ownership and housing characteristics.[29] This index has been
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49 developed and validated in a number of countries to be a robust measure of wealth and
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51 has been found to be consistent with measures of income and expenditure.[30] Briefly,
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3 the measure was constructed as follows. Information on 33 indicators of housing
4 characteristics (e.g., type of windows and flooring, water and sanitation facilities) and
5 assets (e.g., ownership of home, car, computer, mobile phone) were weighted and
6 combined with weights derived from a principal component analysis procedure.[24] The
7 resulting variable was standardized to a mean of 0 and standard deviation of 1 and using
8 this index the household population was divided into fifths from poorest to richest.
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11 Control variables included age, gender, religion, place of residence, and BMI.
12 Age was defined in 10 year categories and centred about its mean (32 years) in regression
13 models. Gender was based on self-report. Religion was categorized as Hindu, Muslim,
14 Sikh, Buddhist, or other religion. Marital status was defined as single, married, widowed,
15 or separated. Place of residence (rural or urban) was defined according to the 2001
16 Census. BMI (in kg/m^2 ; weight in kilograms divided by the square of height in meters)
17 was calculated for all survey respondents with valid measurements for weight and height.
18 BMI was classified according to the following categories based on risk of type 2 diabetes
19 and cardiovascular disease in Asian populations; less than $18.5 \text{ kg}/\text{m}^2$ (underweight);
20 $18.5\text{-}23 \text{ kg}/\text{m}^2$ (acceptable risk); $23\text{-}27.5 \text{ kg}/\text{m}^2$ (increased risk); and $27.5 \text{ kg}/\text{m}^2$ or greater
21 (high risk).[31]
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24 Analysis

25 To account for the complex survey design, we employed multilevel logistic
26 regression to model the probability of diabetes.[32] A three-level model was specified
27 with a binary response (y , diabetes or not) for individual i in local area (village or census
28 block primary sampling units) j in state k . The outcome diabetes, $\text{Pr}(y_{ijk} = 1)$, was
29 assumed to be binomially distributed $y_{ijk} \sim \text{Binomial}(1, \pi_{ijk})$ with probability π_{ijk} related
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3 to the set of independent variables X and a random effect for each level by a logit link
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5 function:

$$6 \quad \text{Logit}(\pi_{ijk}) = \beta_0 + \beta X + u_{0jk} + v_{0k} .$$

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10 The right hand side of the equation consists of the fixed part linear predictor ($\beta_0 + \beta X$)
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12 and random intercepts attributable to local areas (u_{0jk}) and states (v_{0k}). The intercept,
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14 β_0 represents the log odds of diabetes in the reference group, and the β -coefficients
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16 represent the differential in the log odds of diabetes compared to the reference group
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18 defined for each independent variable. Coefficients were exponentiated and presented as
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20 odds ratios for interpretation. The random intercepts are assumed to be independently
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22 and identically distributed and have variances estimated for local areas (σ_u^2) and states
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24 (σ_v^2).[33] The variance parameters quantify heterogeneity in the log odds of diabetes at
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26 each level, after taking into account individual characteristics and place of residence in
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28 the fixed part. We expressed the variances at each level as a percentage of their
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30 contribution to the total variance from an initial model adjusting for age and gender only
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32 and from a final model accounting for all covariates. Models were estimated via Markov
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34 Chain Monte Carlo (MCMC) simulation using the statistical software *MLwiN*. [34-35]
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46 RESULTS

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48 Characteristics of survey respondents by their self-reported diabetes status are
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50 given in **Table 1**. The overall prevalence of diabetes in this sample was 1.5% and this
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52 was higher in urban areas and among men (diabetes prevalence 2.0 % in urban v 1.0% in
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54 rural; 1.8% in men v 1.3% in women). Diabetes prevalence increased with age (7.5% in
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3 50-54y v 0.3% in 18-29y), education (1.9% in higher v 1.0% in no education), household
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6 wealth (2.5% in richest v 0.4% in poorest), and BMI (4.8% in 27.5+ kg/m² v 0.6% in
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8 <18.5 kg/m²). At the state level, the prevalence of diabetes varied between 0.3% in
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10 Rajasthan and 3.3% in Kerala and was generally higher in Southern and Eastern states
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13 **(Figure 1)**.

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15 In separate models that adjusted for age, marital status, religion, and place of
16
17 residence, statistically significant associations were observed between SES and diabetes
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19 for each of the primary indicators of SES in this study: social caste, education, and
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21 household wealth. Compared to the other caste group, scheduled casts, scheduled tribes,
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23 and other backward classes had reduced odds of having diabetes with odds ratios of 0.81
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25 (95% CI: 0.71, 0.94), 0.57 (95% CI: 0.46, 0.70), and 0.84 (95% CI: 0.75, 0.94),
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27 respectively (**Table 2**). Education showed a graded relation with diabetes and an odds
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29 ratio of 1.87 (95% CI: 1.61, 2.18) for those with higher education versus those with no
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31 education. Household wealth showed a graded association with diabetes with individuals
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33 from the richest households having an odds ratio for diabetes of 4.04 (95% CI: 3.08,
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35 5.30) compared to those from the poorest households.

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41 The effects of caste and education were attenuated in the mutually adjusted
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43 model. The reduced odds for diabetes remained consistent for scheduled tribes versus
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45 other caste groups (OR 0.72, 95% CI: 0.58, 0.90) as did an increased odds for those with
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47 secondary education versus no education (OR 1.18, 95% CI: 1.04, 1.35), however the
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49 graded relation with education was less consistent. The strong and graded relation
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51 between household wealth and diabetes remained consistent in this model with an odds
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53 ratio for diabetes of 3.65 (95% CI: 2.83, 4.78) for the richest versus the poorest groups.
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3 Type-2 diabetes is strongly influenced by body weight.[36-38] Therefore, BMI was
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5 added to the final model to control for potential confounding of the SES-diabetes
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7 relationship in this sample. The odds ratios for caste and education remained consistent
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9 between the mutually adjusted model and final model which included BMI. The odds
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11 ratios for household wealth were further attenuated in the final model, however the
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13 positive graded association remained statistically significant with an adjusted odds ratio
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15 for those in the richest compared to the poorest households of 2.58 (95% CI: 1.99, 3.40).
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20 Our analyses revealed dramatic variation in the prevalence of diabetes between
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22 states and local areas in India (**Table 3**). In an initial multilevel model adjusted for age
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24 and gender, states and local areas (defined as villages in rural areas and census blocks in
25
26 urban areas) contributed 5.9% and 10.8%, respectively, to the total variation in diabetes.
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28 The addition of socioeconomic and demographic characteristics along with BMI to the
29
30 model reduced the variance in diabetes attributed to local areas by 41% to 6.4% but the
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32 variation attributed to states was relatively unchanged at 5.4%.
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36 Overall in India, the log odds for diabetes for the reference category (a 32 year old
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38 married women, with no education, BMI < 18.5 kg/m², belonging to the other caste
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40 group, in the poorest fifth of households, and living in a rural area) was -6.13 or a 0.22%
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42 probability of diabetes. Compared to this national reference point, being a resident of
43
44 several Southern and Northeastern states was associated with a statistically significant
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46 increase in the odds of diabetes (**Figure 1**). The odds ratios for these states were 2.29
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48 (Tripura), 1.69 (Tamil Nadu), 1.69 (Kerala), 1.71 (Goa), 1.49 (Andhra Pradesh), and 1.56
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50 (West Bengal). In contrast being resident of the states of Rajasthan, Jammu & Kashmir,
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52 Uttar Pradesh, Punjab, Madhya Pradesh, and Assam in Northern and Central India was
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3 associated with a statistically significant decrease ($OR < 1$) in the odds of reporting
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5 diabetes.
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8 We conducted several sensitivity analyses to assess the consistency of our
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10 findings. First, we examined whether the observed associations were related to
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12 respondents' awareness and knowledge about diabetes. To do so, we considered
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14 responses to the question, "Do you have diabetes?" as a categorical variable, comparing
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16 "yes" and "don't know" versus "no" across the same set of independent variables using a
17
18 multinomial logistic model. Associations between SES variables and positive reports of
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20 diabetes from this model, which included the possibility that respondents were unaware
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22 of their diabetes status, were nearly identical to findings from the logistic model which
23
24 excluded those with unknown diabetes status (**Supplemental table 1**). The multinomial
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26 model also revealed that the richer and more highly educated respondents were less likely
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28 to report "do not know" as their diabetes status (compared to "no"). In addition, we
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30 examined BMI across the three categories of diabetes status (**Figure 3**). This revealed
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32 that those reporting "do not know" had the lowest BMI (mean 20.9, SD 3.7) which was
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34 largely consistent with the "no" group (mean 21.1, SD 3.9) and substantially lower than
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36 those reporting "yes" to diabetes (mean 24.4, SD 4.9). Finally, we examined interactions
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38 between socioeconomic variables (caste, education, wealth) and diabetes by residential
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40 location. Tests of these interactions were not statistically significant ($P=0.20$ for caste;
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42 $P=0.72$ for education; $P=0.66$ for wealth).
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DISCUSSION

In this study, we have two key findings. First, measures of SES were positively associated with self-reported diabetes in the NFHS-3. Although the observed effects of caste and education were largely attenuated in fully adjusted models, the effect of household wealth remained positive, graded and statistically significant even after controlling for BMI. Second, we observed a large variation in the prevalence of diabetes between local areas and States in India. A few Southern and northeastern states were associated with a higher risk for reporting diabetes while several northern and central states were at lower risk after adjusting for individual characteristics and place of residence.

There are a few limitations to our study. First, the outcome was defined on the basis of self-reported diabetes, although interviews were conducted in person using a standardized instrument. Previous research has shown good agreement for self-reported diabetes when compared to medical records in a US population.[39] In addition, our sensitivity analyses considering respondents who reported “did not know” for their diabetes status were nearly identical to the main analyses. We find, however, evidence that higher SES groups were less likely to report “did not know” as compared to “no”, which has been suggested previously on studies using self-reports of diabetes status in India.[6] However, the “did not know” group was more similar in terms of BMI, education, and wealth to the “no” rather than “yes” group. In addition, our sample was relatively young (<55 y for men and <50 y for women). The prevalence of diabetes increases with age and whether a similar SES-diabetes relationship exists among middle and older age groups in India is not clear.

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3 Our findings of positive SES-diabetes associations are consistent with previous
4 studies done in different parts of India. For example, an analysis of rural participants
5 from the Indian Migration Study, which sampled primarily from four large states in the
6 north, centre, and south of India [8], identified a positive SES-diabetes gradient among
7 men (8.0% prevalence in high SES group v 1.8% in low SES group), and a weaker
8 positive SES-diabetes association that was not statistically significant among women
9 (5.1% v 3.9%). In addition, a study done in an urban setting in Madras (Chennai) found
10 an odds ratio for diabetes of 2.2 (95% credible interval [CI]: 1.7-2.7) for high v low SES
11 groups.[9] One larger study conducted in urban and rural surveillance locations in
12 Northern, Southern, Eastern, and Western/Central India identified an odds ratio of 3.0
13 (95% CI: 2.5-3.7) for self-reported diabetes for those with graduate level education
14 versus those without formal schooling.[6] Importantly, these studies were limited to
15 selected geographical areas or cities in India. Our study has added to this literature using
16 a national population health survey with good coverage in rural areas across India.
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36 Previous research in India has identified a strong positive relation between SES
37 and BMI among women and men in India. [40-42] These studies are important because
38 they have used similar markers of SES in the Indian context along with an objectively
39 defined outcome (height and weight were measured in NFHS and not self-reported).
40 BMI (along with other measures of body weight) is an important risk factor for the
41 development of type 2 diabetes. [36 38 43] Therefore, the consistency of our findings of a
42 positive SES-diabetes association after controlling for BMI is encouraging. If BMI is
43 part of the causal pathway between SES and diabetes, attenuation in the effect size for
44 markers of SES would be expected. The graded and positive relation between household
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3 wealth and diabetes after accounting for BMI suggests that there are additional effects of
4 household wealth on diabetes that are not mediated by BMI.
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8 When compared to other studies in India, the overall prevalence of diabetes in the
9 NFHS-3 was not high. This may have resulted from a combination of using self-reports
10 of diabetes, the younger age of the NFHS-3 target population, and sampling from the
11 general population which included a high proportion of respondents in rural areas.
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15 Among individuals over 30 years of age, the prevalence was 2.5% (3.0 % in men and
16 2.2% in women). Other studies using in rural India using similar age groups and blood
17 measurements have reported diabetes prevalence of 4% and a study from rural Andhra
18 Pradesh found a prevalence of 12% based on combination self-report and blood
19 measurements.[8 44]
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29 The current national estimate for diabetes prevalence in India is about 7% of the
30 adult population aged 20-79. This estimate is based on 3 relatively recent and larger
31 scale studies using a combination of oral glucose tolerance testing and self-reports of
32 diabetes.[4-6] There continues to be considerable uncertainty in estimates of diabetes for
33 the whole of India due to the limited study locations (with a focus on urban areas), wide
34 variation in survey sampling methodology, differences in diabetes diagnostic criteria, and
35 age groups studied. These differences in study design have hindered direct comparison
36 of the prevalence between studies, across regions and over time. The NFHS-3 provides
37 and important benchmark because it is the first nationally-representative survey of
38 diabetes in India. Even if the prevalence estimates of diabetes have been underestimated
39 in the NFHS-3, the observed SES-diabetes associations are plausible and important.
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3 markers, which may be a key determinant of diabetes. Further large-scale population-
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5 based surveys can be strengthened by using simple finger-prick blood glucose
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7 measurements in addition to self-reports.
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11 There has been considerable concern over the rising prevalence of diabetes in
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13 India, especially with studies on migrant Indian populations suggesting that South Asians
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15 may be more susceptible to the disease. In light of current findings, it appears that, at
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17 present, the more well-off segments of the Indian population are at greatest risk. This
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19 poses concerns on how to appropriately balance priorities to address the disease burden
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21 that afflicts the non poor versus the poor in the context of India where 40-50 percent[45]
22
23 of the population are poor.
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29 **ACKNOWLEDGEMENTS**

30
31 SVS and DJC planned the study. DJC conducted statistical analyses and drafted the
32
33 manuscript with supervision from SVS. Both authors participated in interpretation of the
34
35 results and critical revisions of the manuscript.
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39 The NFHS data are available through the Measure DHS project at www.measuredhs.com.
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Table 1: Characteristics of survey participants and frequency distribution of self-reported diabetes in India, males and females from the 3rd National Family Health Survey

	Diabetes		Total
	n	%	n
Participants	2439	1.5	168135
Residence			
Rural	818	1.0	86013
Urban	1621	2.0	82122
Age group			
18-29 y	266	0.3	76174
30-39 y	602	1.2	51132
40-49 y	1238	3.4	36402
50-54 y	333	7.5	4427
Gender			
Male	1144	1.8	65255
Female	1295	1.3	102880
Marital status			
Single	132	0.3	38078
Married	2165	1.8	123457
Widowed	108	2.5	4320
Divorced or separated	34	1.5	2280
Religion			
Hindu	1775	1.4	123411
Muslim	340	1.6	21510
Christian	213	1.4	14779
Sikh	49	1.5	3236
Buddhist	34	1.4	2451
Other	28	1.0	2748
Social Caste			
Other caste	1026	1.8	56063
Scheduled caste	349	1.3	27677
Scheduled tribe	167	0.8	21372
Other backward class	781	1.4	55641
No caste	116	1.6	7382
Education			
No education	464	1.0	44856
Primary	358	1.4	24969
Secondary	1166	1.6	74715

Higher	451	1.9	23595
Household wealth			
Poorest	77	0.4	17252
2	175	0.8	22948
3	278	0.9	32070
4	573	1.4	42091
Richest	1336	2.5	53774
Body mass index (kg/m ²)			
<18.5	243	0.6	42128
18.5-23	703	0.9	74089
23-27.5	833	2.7	31217
27.5+	547	4.8	11502

Table 2: Associations between socioeconomic status and self-reported diabetes in India;
3rd National family health survey

Variable	Model adjusted for age, gender, marital status, religion, residence		Mutually adjusted model		Mutually adjusted model with BMI	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Caste						
Other caste	1.00		1.00		1.00	
Scheduled caste	0.81	0.71 , 0.94	1.05	0.91 , 1.21	1.07	0.93 , 1.24
Scheduled tribe	0.57	0.46 , 0.70	0.72	0.58 , 0.90	0.73	0.57 , 0.92
Other backward caste	0.84	0.75 , 0.94	0.95	0.85 , 1.07	0.96	0.86 , 1.08
No caste	0.89	0.71 , 1.11	0.94	0.75 , 1.17	0.95	0.76 , 1.20
Wealth						
Poorest	1.00		1.00		1.00	
2nd quintile	1.59	1.20 , 2.12	1.57	1.21 , 2.07	1.49	1.14 , 1.96
3rd quintile	1.63	1.23 , 2.16	1.55	1.21 , 2.02	1.39	1.07 , 1.81
4th quintile	2.42	1.85 , 3.17	2.25	1.76 , 2.92	1.79	1.40 , 2.34
Richest	4.04	3.08 , 5.30	3.65	2.83 , 4.78	2.58	1.99 , 3.40
Education						
No education	1.00		1.00		1.00	
Primary	1.23	1.06 , 1.43	1.06	0.91 , 1.22	1.00	0.86 , 1.17
Secondary	1.68	1.49 , 1.90	1.18	1.04 , 1.35	1.12	0.98 , 1.28
Higher	1.87	1.61 , 2.18	1.12	0.95 , 1.32	1.01	0.86 , 1.20
Body mass index						
<18.5					1.00	
18.5-23					1.25	1.08 , 1.46
23-27.5					2.08	1.79 , 2.44
27.5+					2.98	2.51 , 3.54

Table 3: Variance in self-reported diabetes status between local areas and states in India; expressed as percentage of the contribution to the total variance in diabetes

	Age & gender adjusted*			Fully adjusted**		
	Variance	SE	%	Variance	SE	%
States	0.231	0.076	5.9	0.204	0.068	5.4
Local areas	0.425	0.043	10.8	0.240	0.041	6.4

*Multilevel model adjusted for age and gender only

**Multilevel model fully adjusted for age, gender, marital status, religion, social caste, household wealth, education, body mass index, and place of residence

FIGURE LEGENDS

Figure 1 State level prevalence of self-reported diabetes in India for men aged 18-54 (left) and women aged 18-49 (right). Darker colours indicate higher prevalence.

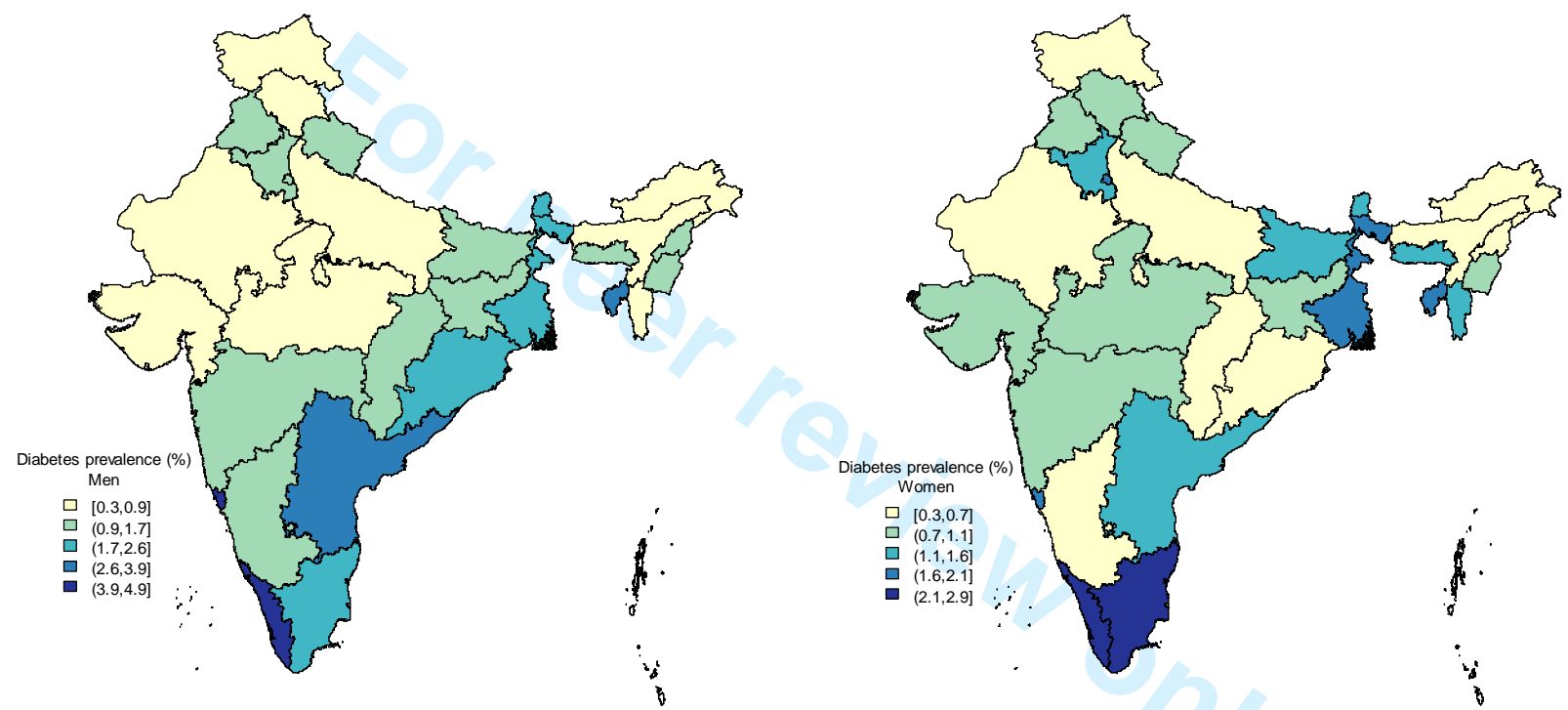
Figure 2 Odds ratios for self-reported diabetes by state of residence in India; adjusted for age, gender, marital status, religion, social caste, household wealth, education, body mass index and place of residence.

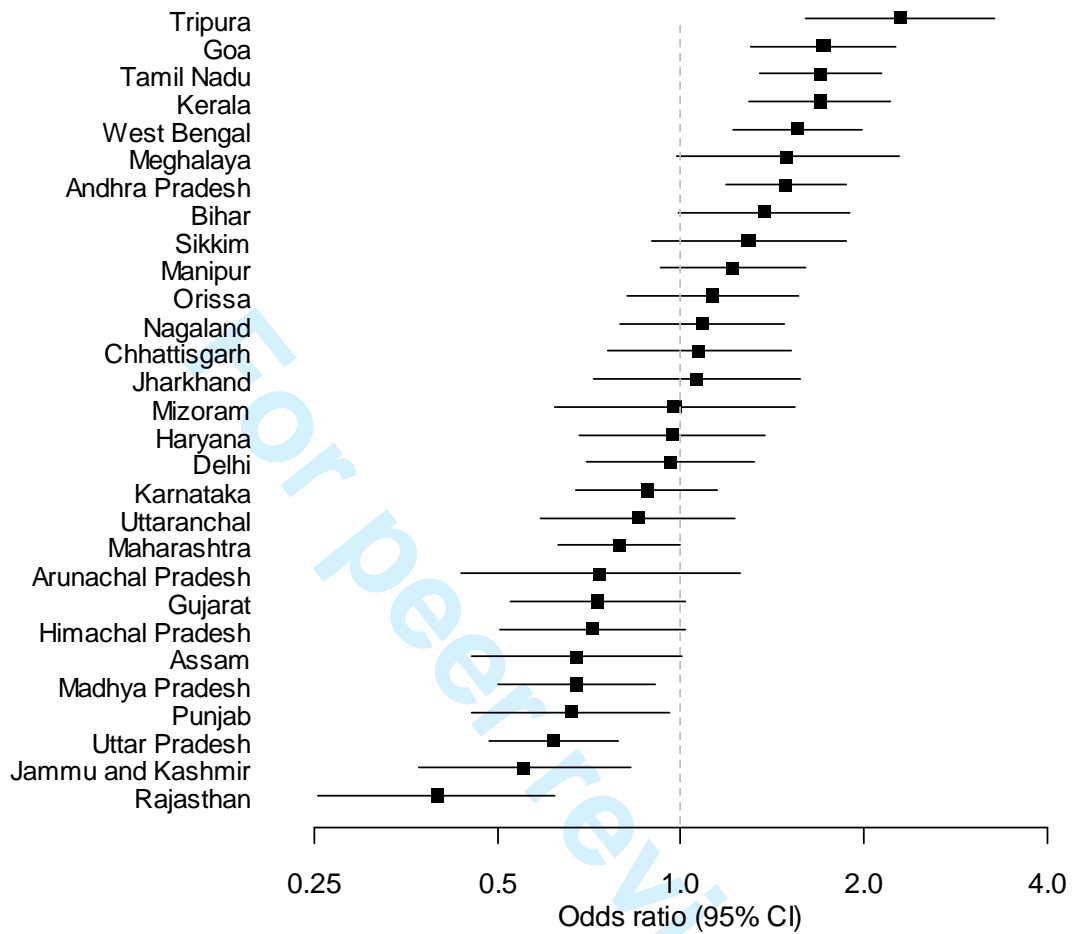
Figure 3 Mean body mass index across three possible responses for self-reported diabetes (diabetes status not known, No- do not have diabetes, Yes- have diabetes). Vertical lines represent 95% confidence intervals. Body mass index (in kg/m²) objectively defined based on measured height and weight values.

Supplementary Table 1 Associations between socioeconomic status, self-reported diabetes, and unknown diabetes status using a multinomial regression model.

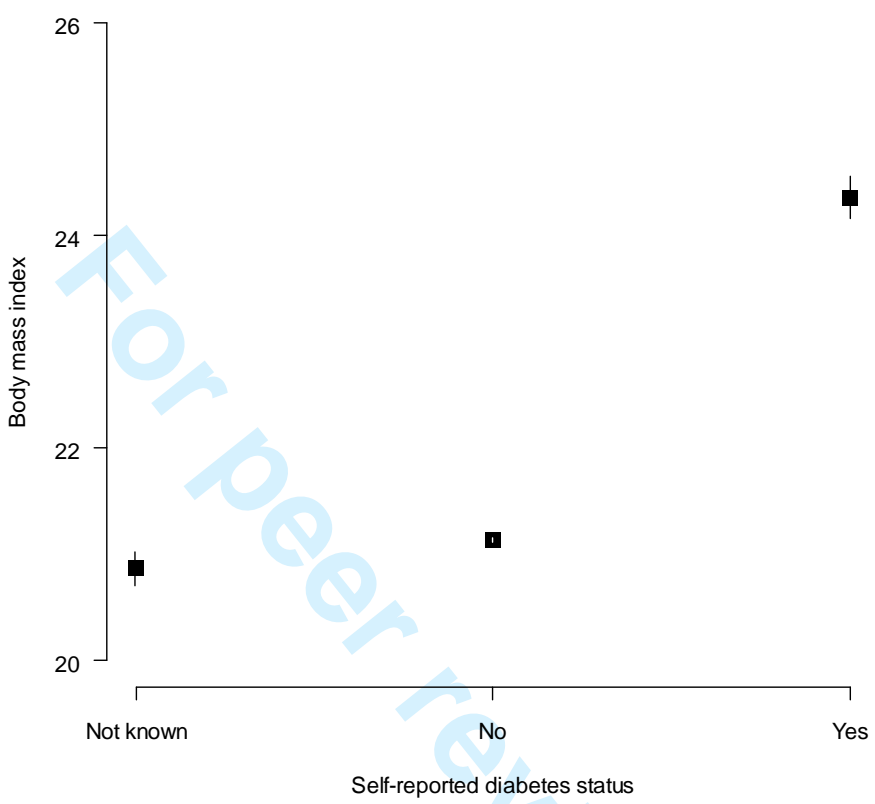
Variable	Diabetes		Diabetes not known	
	Odds ratio	95% CI	Odds ratio	95% CI
Caste				
Other caste	1.00		1.00	
Scheduled caste	1.07	0.93 , 1.24	1.13	0.96 , 1.31
Scheduled tribe	0.73	0.58 , 0.91	1.52	1.25 , 1.84
Other backward caste	0.96	0.86 , 1.08	1.07	0.93 , 1.23
No caste	0.95	0.75 , 1.18	0.76	0.58 , 0.99
Wealth				
Poorest	1.00		1.00	
2nd quintile	1.51	1.14 , 2.03	0.90	0.77 , 1.05
3rd quintile	1.41	1.07 , 1.89	0.86	0.73 , 1.01
4th quintile	1.82	1.38 , 2.44	0.82	0.68 , 0.98
Richest	2.63	1.97 , 3.56	0.64	0.51 , 0.79
Education				
No education	1.00		1.00	
Primary	1.00	0.87 , 1.17	0.86	0.76 , 0.99
Secondary	1.12	0.98 , 1.28	0.71	0.63 , 0.81
Higher	1.01	0.85 , 1.21	0.45	0.36 , 0.57
Body mass index				
<18.5	1.00		1.00	
18.5-23	1.26	1.08 , 1.46	1.03	0.93 , 1.15
23-27.5	2.09	1.79 , 2.45	1.17	1.01 , 1.36
27.5+	2.99	2.52 , 3.55	1.33	1.06 , 1.66

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Article: Association between socioeconomic status and diabetes in India

Authors: Daniel J Corsi, SV Subramanian

	Item No	Recommendation
Title and abstract	1	(a) Design cross-sectional study, listed in abstract (b) abstract and article summary (page 3)
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported, (abstract, page 3, page 4-5)
Objectives	3	State specific objectives, including any prespecified hypotheses (abstract, page 3, page 4-5)
Methods		
Study design	4	Present key elements of study design early in the paper (abstract, page 6)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection (abstract, page 5-7)
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants (page 6)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable (page 7)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group (page 7-8)
Bias	9	Describe any efforts to address potential sources of bias (page 8-9; page 12)
Study size	10	Explain how the study size was arrived at (page 7)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why (page 8)
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (page 8-9) (b) Describe any methods used to examine subgroups and interactions (page 12) (c) Explain how missing data were addressed (page 7) (d) If applicable, describe analytical methods taking account of sampling strategy (page 8) (e) Describe any sensitivity analyses (page 12)
Results		
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (page 8) (b) Give reasons for non-participation at each stage (n/a) (c) Consider use of a flow diagram (n/a)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (page 9-10, table 1) (b) Indicate number of participants with missing data for each variable of interest (page 7; page 12)
Outcome data	15*	Table 1
Main results	16DJC	(a) Tables 1 (unadjusted), 2 (age, gender, marital status, religion, place of residence adjusted; and fully adjusted model)

		(b) Report category boundaries when continuous variables were categorized (in methods, e.g. for BMI)
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period (n/a)
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses (Page 12)
Discussion		
Key results	18	Summarise key results with reference to study objectives (page 13)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (page 13)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (page 16)
Generalisability	21	Discuss the generalisability (external validity) of the study results (pages 14-15)
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (title page)

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.



Association between socioeconomic status and self-reported diabetes in India: a cross-sectional multilevel analysis

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5 cross-sectional multilevel analysis
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7

8 **Authors and affiliation**
9

10 Daniel J Corsi, MSc, Population Health Research Institute, McMaster University,
11
12 Hamilton, ON, Canada
13

14 SV Subramanian, PhD, Professor of Population Health and Geography,
15
16 Department of Society, Human Development, and Health, Harvard School of Public
17
18 Health, Boston, MA, USA
19
20
21

22 **Corresponding author details**
23

24 Professor S V Subramanian, Harvard School of Public Health, 677 Huntington Avenue,
25
26 Boston MA 02115, USA; Tel: 617-432-6299; Fax: 617-432-3123; Email:
27
28

29 svsubram@hsph.harvard.edu
30
31

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ABSTRACT

Objectives To quantify the association between socioeconomic status (SES) and type-2 diabetes in India

Design Nationally representative cross-sectional household survey

Setting Urban and rural areas across 29 states in India

Participants 168,135 survey respondents aged 18-49 y (women) and 18-54 y (men)

Primary outcome measure Self-reported diabetes status

Results Markers of SES were social caste, household wealth, and education. The overall prevalence of self-reported diabetes was 1.5%; this increased to 1.9% and 2.5% for those with the highest levels of education and household wealth, respectively. In multilevel logistic regression models (adjusted for age, gender, religion, marital status, and place of residence) education (odds ratio 1.87 for higher education vs no education) and household wealth (odds ratio 4.04 for richest quintile vs poorest) were positively related to self-reported diabetes ($P < 0.0001$). In a fully adjusted model including all socioeconomic variables and body mass index (BMI), household wealth emerged as positive and statistically significant with an odds ratio for self-reported diabetes of 2.58 (95% credible interval [CrI]: 1.99-3.40) for the richest quintile of household wealth versus the poorest. Nationally in India a one-quintile increase in household wealth was associated with an odds ratio of 1.31 (95% CrI: 1.20-1.42) for self-reported diabetes. This association was consistent across states with the relationship found to be positive in 97% (28 of 29 states) and statistically significant in 69% (20 of 29).

Conclusions We found that the highest socioeconomic status groups in India appear to be at greatest risk for type-2 diabetes. This raises important policy implications for

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addressing the disease burdens among the poor versus those among the non poor in the context of India, where greater than 40 percent of the population is living in poverty.

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ARTICLE SUMMARY

Article Focus

- The relationship between socioeconomic factors and type-2 diabetes has not been previously studied for the whole of India and across states
- Our objective was to investigate associations between measures of socioeconomic status (defined as social caste, education, household wealth) and self-reported diabetes status in India
- In addition we explored geographic variation in the prevalence of diabetes between states and local areas in India and between-state variability in the SES-diabetes relationship

Key messages

- The highest socioeconomic groups appear to be at greatest risk for diabetes in India; with the strength of the association consistent in size and magnitude across states
- There is substantial geographic heterogeneity in the prevalence of diabetes
- These findings raise important policy implications for in addressing the disease burdens among the poor versus those among the non poor in the context of India, where nearly half of the population is living in poverty.

Strengths and Limitations

- The key strength of this study is the use of a large, nationally-representative survey to assess the socioeconomic and geographic patterning of diabetes across all of India. Limitations include the relatively younger age of the sample and assessment of diabetes status on the basis of self-reports.

INTROCUCTION

The prevalence of type-2 diabetes in India has been investigated in numerous population based surveys conducted across a range of settings since the 1970s.[1-6] Despite multiple prevalence studies, no nationally representative studies exist which have considered the association between socioeconomic status (SES) and type-2 diabetes in India. In a review of 15 existing studies which have reported the prevalence of type-2 diabetes by SES and/or associations between SES and type-2 diabetes, all were found to have been based on local or regional samples and a majority were done in urban areas[4 6-19] (**Table 1**). It has been suggested that the prevalence of type-2 diabetes and other cardiovascular disease risk factors may increasingly become concentrated among low SES groups in India[20] and other low- and middle-income countries[21], although to date the empirical evidence from India in support of this hypothesis remains limited. The majority of studies reviewed in table 1 have provided evidence of a positive association between SES (defined as education, household wealth, social caste, or a composite of 2 or more markers) and diabetes among populations from selected geographic regions in India [6 11 17]; however the strength and consistency of this association across the whole of India has not previously been assessed.

Type-2 diabetes is the most common form of diabetes globally, accounting for greater than 85% of cases.[22] The incidence of type-2 diabetes is related to genetic and non-genetic components, with the latter being greatly influenced by modifiable risk factors such as obesity, diets low in fibre and high in trans fat, and physical inactivity.[23-24] Lifestyle behaviours are strongly patterned by SES [25], and may be mediators on the causal pathway between SES and the onset of type-2 diabetes.[26] In

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3 high income countries, the SES-diabetes relationship appears to be negative, with the
4 poor at greatest risk. For example, strong associations have been observed between
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6 poverty, low education and type-2 diabetes among African American women [27-28],
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8 and among White women and men in the United States.[29] Similarly, a study from
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10 Canada described an inversely graded SES-diabetes association with an odds ratio of 1.9
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12 for men (95% CI: 1.6-2.4) and 2.8 (95% CI: 2.2-3.4) for women for the lowest versus
13
14 highest income groups.[30] A recent meta-analysis of 23 case-control and cohort studies
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16 and 43 measures of SES-diabetes association revealed an overall increased risk for type-2
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18 diabetes for low SES groups based on education, occupation, and income.[31] The
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20 strength of the association, however, was less consistent in low and middle income
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22 countries (LMICs), and few studies have been conducted in these countries.
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29 Concern has been raised over the anticipated rapid increase in type-2 diabetes
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31 prevalence in India.[32-33] Evidence on the secular increases in diabetes prevalence in
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33 India, however, have been limited to urban areas of Southern India[4 34-35], and have
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35 focused on the mean rates of diabetes rather than how it is distributed in the population.
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37 In this paper we address the need to comprehensively investigate the socioeconomic and
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39 geographic distribution of type-2 diabetes in the Indian population using a large-scale
40
41 nationally representative survey. Specifically, we investigate the SES-diabetes
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43 association through the SES markers of social caste, household wealth, and education. In
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45 addition, we investigate the geographic distribution of the prevalence of diabetes across
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47 states and local areas along with variability in the SES-diabetes association across states.
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55 **METHODS**

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Data source

We use data from the 3rd National Family Health Survey (NFHS), conducted in 29 states in India between November 2005 and August 2006.[36] NFHS-3 is a major national health survey in India which collected information on a range of indicators including reproductive health, nutritional status of adults and children, utilization of health care services, and blood testing for HIV prevalence. NFHS-3 covered all states in India, which comprise nearly 99% of the population, but excluded Union Territories. The survey was designed to provide estimates of key indicators (except HIV prevalence) for each state by urban and rural areas.

Survey design

A uniform multistage sampling strategy was adopted in all states, with separate sampling in urban and rural areas.[37-38] In rural areas, a two stage sample was carried out using a list of villages from the 2001 census as the sampling frame. In the first stage, a stratified sample of villages was drawn with probability proportional to the size of the village. In the second stage, a random selection of households was drawn in each village from a complete list of households compiled during field visits carried out in each sampled village. In urban areas, a similar procedure was implemented beginning with a stratified random sample of municipal wards based on the 2001 census. Next, one census enumeration block (150-200 households) was selected from within wards using probability proportional to size. Finally, as in rural areas, field enumerators undertook a household listing operation in selected blocks and a random sample of households was made. In both rural and urban areas, 30 households were targeted for selection in each of the sampled units. The overall household response rate for NFHS-3 was 98%.[36]

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2
3 All women aged 15-49 in selected households were invited to participate in the
4 survey. In 22 states, men aged 15-54 in a random subsample of households drawn from
5 each PSU (about 6 households per PSU) were eligible for the men's survey. In the
6 remaining seven states (Andhra Pradesh, Karnataka, Maharashtra, Manipur, Tamil Nadu,
7 Uttar Pradesh, and Nagaland) eligible men all in selected households were invited to
8 participate. The additional men recruited in these states was for the purpose of HIV
9 testing to provide reliable state level estimates of HIV prevalence in certain states.
10 Interviews were conducted in 1 of the 18 Indian languages in the respondent's home and
11 the response rates were 95% for women and 87% for men.[36] During interviews, the
12 weights and heights of survey respondents were measured by trained field technicians
13 using standardized measuring equipment designed for survey settings.[39]

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In total NFHS-3 collected information from 109,041 households, 124,385 women from 15 to 49 years of age, and 74,369 men from 15 to 54 years of age. We restricted our analyses to adults aged 18 years and older and non-pregnant women (n=171,207). Respondents who did not report or know their diabetes status (n= 2,373) or with incomplete information for any of the independent variables considered in the analysis (marital status, religion, caste, education, household wealth) were excluded (n=699). Main analyses were conducted on a sample of 168,135 respondents, (65,255 men and 102,880 women). Additional analyses considering body mass index (BMI) were restricted to a sample of 158,936 due to missing and/or implausible values for height and/or weight. **Figure 1** provides a flow diagram detailing the NFHS sample, exclusions, and final analytic sample sizes.

Outcome and independent variables

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The primary outcome was diabetes, assessed on the basis of self-reports by survey respondents. Markers of socioeconomic status were social caste, household wealth, and education. Social caste was reported by the household head. The categories were Other Caste, Scheduled caste, Scheduled tribe, Other Backward Class, and No Caste. Other Caste is a heterogeneous group that is traditionally viewed as having higher social status. Scheduled castes and scheduled tribes are considered lower, socially marginalized groups in India.[40] Household wealth was defined by an index based on indicators of asset ownership and housing characteristics.[41] This index has been developed and validated in a number of countries to be a robust measure of wealth and has been found to be consistent with measures of income and expenditure.[42] Briefly, the measure was constructed as follows. Information on 33 indicators of housing characteristics (e.g., type of windows and flooring, water and sanitation facilities) and assets (e.g., ownership of home, car, computer, mobile phone) were weighted and combined with weights derived from a principal component analysis procedure.[36] The resulting variable was standardized to a mean of 0 and standard deviation of 1 and using this index the household population was divided into fifths from poorest to richest. Education was categorized in four levels as no education, primary, secondary, or higher education.

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Background characteristics included age, gender, religion, marital status, place of residence, and BMI. Age was defined in 10 year categories and centred about its mean (32 years) in regression models. Gender was based on self-report. Religion was categorized as Hindu, Muslim, Sikh, Buddhist, or other religion. Marital status was defined as single, married, widowed, or separated. Place of residence (rural or urban) was defined according to the 2001 Census. BMI (in kg/m^2 ; weight in kilograms divided

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3 by the square of height in meters) was calculated for all survey respondents with valid
4 measurements for weight and height. BMI was classified according to the following
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6 categories based on risk of type 2 diabetes and cardiovascular disease in Asian
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8 populations; less than 18.5 kg/m² (underweight); 18.5-22.9 kg/m² (acceptable risk); 23-
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10 27.4 kg/m² (increased risk); and 27.5 kg/m² or greater (high risk).[43]
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13 14 15 **Analysis**

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17 To account for the complex survey design, we employed multilevel logistic
18 regression to model the probability of diabetes.[44] A three-level model was specified
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20 with a binary response (y, diabetes or not) for individual *i* in local area (village or census
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22 block primary sampling units) *j* in state *k*. The outcome diabetes, Pr($y_{ijk} = 1$), was
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24 assumed to be binomially distributed $y_{ijk} \sim \text{Binomial}(1, \pi_{ijk})$ with probability π_{ijk} related
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26 to the set of independent variables *X* and a random effect for each level by a logit link
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28 function:
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$$33 \text{Logit}(\pi_{ijk}) = \beta_0 + \beta X_{ijk} + v_{0k} + u_{0jk} \cdot \text{ (Equation 1)}$$

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35 The right hand side of the equation consists of the fixed part linear predictor ($\beta_0 + \beta X_{ijk}$)
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37 and random intercepts attributable to states (v_{0k}) and local areas (u_{0jk}). The intercept,
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39 β_0 represents the log odds of diabetes in the reference group, and the β -coefficients
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41 represent the differential in the log odds of diabetes compared to the reference group
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43 defined for each independent variable. Coefficients were exponentiated and presented as
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45 odds ratios for interpretation. The random intercepts are assumed to be independently
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47 and identically distributed and have variances estimated for states (σ_v^2) and local areas
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49 (σ_u^2).[45] The variance parameters quantify heterogeneity in the log odds of diabetes at
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3 each level, after taking into account individual characteristics and place of residence in
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5 the fixed part. We expressed the variances at each level as a percentage of their
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7 contribution to the total variance from an initial model adjusting for age and gender only
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9 and from a final model accounting for all covariates. We specified a sequence of six
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11 models during analyses. In the first three models, one SES marker (social caste,
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13 household wealth, education) was added to a model which adjusted for background
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15 characteristics (age, gender, religion, and place of residence). In the fourth mutually
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17 adjusted model, all SES markers were included along with background characteristics
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19 from the previous models. In the fifth model, BMI was included with markers of SES and
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21 background characteristics from model 4. In the sixth model, we also tested whether the
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23 association between household wealth varied across states in terms of strength or
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25 direction, given that different states vary tremendously by levels of economic
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27 development and could be considered at different levels of epidemiological transition. In
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29 order to test this between state variability we expanded Equation 1 to allow the slope of
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31 household wealth to vary across states:
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$$\text{Logit}(\pi_{ijk}) = \beta_0 + \beta_{1k} \text{wealth}_{ijk} + \beta X_{ijk} + v_{0k} + v_{1k} + u_{0jk} . \text{ (Equation 2)}$$

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35 The key feature of Equation 2 is that the effect of wealth on self-reported diabetes in state
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37 k consists of the overall average effect across all states (β_1), plus a state-specific (v_{1k})
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39 differential in this effect. We summarized and presented the results of this model as the
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41 odds ratio for self-reported diabetes overall in India and for each state given a 1-quintile
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43 increase in household wealth and conditional on all covariates from model 5. Additional
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45 analyses were carried out separately for male and female samples using an identical
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47 sequence of models (with the exclusion of gender as a background characteristic).
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3 Estimation of models was done using Markov Chain Monte Carlo (MCMC) simulation
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5 and the statistical software *MLwiN*.^[46-47]
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10 RESULTS

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12 Characteristics of survey respondents by their self-reported diabetes status are
13 given in **Table 2**. The overall prevalence of diabetes in this sample was 1.5% and this
14 was higher in urban areas and among men (diabetes prevalence 2.0 % in urban v 1.0% in
15 rural; 1.8% in men v 1.3% in women). Diabetes prevalence increased with age (7.5% in
16 50-54y v 0.3% in 18-29y), education (1.9% in higher v 1.0% in no education), household
17 wealth (2.5% in richest v 0.4% in poorest), and BMI (4.8% in 27.5+ kg/m² v 0.6% in
18 <18.5 kg/m²). At the state level, the prevalence of diabetes varied between 0.3% in
19 Rajasthan and 3.3% in Kerala and was generally higher in Southern and Eastern states
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(**Figure 2**).

In separate models that adjusted for age, marital status, religion, and place of residence, statistically significant associations were observed between SES and self-reported diabetes for each of the primary markers of SES in this study: social caste, household wealth, and education. Compared to the other caste group, scheduled casts, scheduled tribes, and other backward classes had reduced odds of having diabetes with odds ratios of 0.81 (95% CI: 0.71-0.94), 0.57 (95% CI: 0.46-0.70), and 0.84 (95% CI: 0.75-0.94), respectively (**Table 3**, Models 1-3). Education showed a graded relation with diabetes and an odds ratio of 1.87 (95% CI: 1.61-2.18) for those with higher education versus those with no education. Household wealth showed a graded association with

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3 diabetes with individuals from the richest households having an odds ratio for diabetes of
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5 4.04 (95% CI: 3.08-5.30) compared to those from the poorest households.
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8 The effects of social caste and education were attenuated in the mutually adjusted
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10 model (model 4), suggesting that their independent effects on self-reported diabetes were
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12 at least partially mediated by the inclusion of household in this model. The reduced odds
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14 for diabetes remained consistent for scheduled tribes versus other caste groups (OR 0.72,
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16 95% CI: 0.58-0.90) as did an increased odds for those with secondary education versus
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18 no education (OR 1.18, 95% CI: 1.04-1.35), however the graded relation with education
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20 was less consistent. In separate mutually adjusted models that were stratified by gender,
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22 education showed a graded association in men although it was not statistically significant
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24 with the odds ratio for diabetes men found to be 1.27 (95% CI: 0.98-1.70) for men with
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26 higher versus no education (**Supplemental Table 1**). Among women, those with
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28 secondary education continued to show an increased odds of self-reported diabetes
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30 compared to those with no education (OR 1.28, 95% CI: 1.08-1.50). Overall, the strong
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32 and graded relation between household wealth and diabetes remained consistent in model
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34 4 with an odds ratio for diabetes of 3.65 (95% CI: 2.83, 4.78) for the richest versus the
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36 poorest groups; similar associations were found in the gender-specific models
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38 (Supplemental Table 1). Type-2 diabetes is strongly influenced by body weight.[48-50]
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40 Therefore, BMI was added to model 5 to control for potential confounding of the SES-
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42 diabetes relationship in this sample. In addition, BMI was added separately in this model
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44 because its inclusion resulted in the reduction of sample size by ~5% due to missing
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46 values for BMI. The odds ratios for caste and education remained consistent between
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48 the mutually adjusted model and final model which included BMI. The odds ratios for
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3 household wealth were further attenuated in the final model, however the positive graded
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5 association remained statistically significant with an adjusted odds ratio for those in the
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7 richest compared to the poorest households of 2.58 (95% CI: 1.99-3.40).
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11 Our analyses revealed dramatic variation in the prevalence of diabetes between
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13 states and local areas in India (**Table 4**). In an initial multilevel model adjusted for age
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15 and gender, states and local areas (defined as villages in rural areas and census blocks in
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17 urban areas) contributed 5.9% and 10.8%, respectively, to the total variation in diabetes.
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19 The addition of socioeconomic and demographic characteristics along with BMI to the
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21 model reduced the variance in diabetes attributed to local areas by 41% to 6.4% but the
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23 variation attributed to states was relatively unchanged at 5.4%.
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28 Overall in India, the log odds for diabetes for the reference category (a 32 year old
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30 married women, with no education, BMI <18.5 kg/m², belonging to the other caste group,
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32 in the poorest fifth of households, and living in a rural area) was -6.13 or a 0.22%
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34 probability of diabetes. Compared to this national reference point, being a resident of
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36 several Southern and Northeastern states was associated with a statistically significant
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38 increase in the odds of diabetes (**Figure 3**). The odds ratios for self-reported diabetes
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40 these states were: 2.29 (Tripura), 1.69 (Tamil Nadu), 1.69 (Kerala), 1.71 (Goa), 1.49
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42 (Andhra Pradesh), and 1.56 (West Bengal). In contrast being resident of the states of
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44 Rajasthan, Jammu & Kashmir, Uttar Pradesh, Punjab, Madhya Pradesh, and Assam in
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46 Northern and Central India was associated with a statistically significant decrease (OR <
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48 1.0) in the odds of self-reported diabetes.
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54 In order to assess the variability in the SES-diabetes association across states in
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56 India, a final model (model 6) was specified to allow the odds ratio for diabetes for a one-
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3 quintile increase in household wealth to vary across states. In this model, the overall
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5 odds ratio for diabetes in India for a one-quintile increase in household wealth was 1.31
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7 (95% CI: 1.20-1.42) (**Figure 4**). In 15 states, the association was stronger than the
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9 national average; varying between an odds ratio of 1.33 in Rajasthan and 1.55 in Jammu
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11 & Kashmir. Although the association was less than the national average in 14 states, it
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13 was found to be positive in 28/29 (97%) states and statistically significant in 20/29
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15 (69%). Only in West Bengal was an inverse association observed, but it was not
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17 statistically significant (OR 0.95 95% CI: 0.83-1.09). Odds ratios and 95% CI for the
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19 overall association and across all states are presented in **Supplemental Table 2**. In
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21 summary, the association between household wealth and self-reported diabetes was
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23 consistent across the states both in direction and magnitude.
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29 We conducted several sensitivity analyses to assess the consistency of our
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31 findings. First, we examined whether the observed associations were related to
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33 respondents' awareness and knowledge about diabetes. To do so, we considered
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35 responses to the question, "Do you have diabetes?" as a categorical variable, comparing
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37 "yes" (diabetic) and "don't know" (unknown) versus "no" (non-diabetic) across the same
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39 set of independent variables using a multinomial logistic model. Associations between
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41 SES variables and positive reports of diabetes from this model, which included the
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43 possibility that respondents were unaware of their diabetes status, were nearly identical to
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45 findings from the logistic model which excluded those with unknown diabetes status
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47 (**Supplemental Table 3**). The multinomial model also revealed that the richer and more
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49 highly educated respondents were less likely to report unknown status compared to non-
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51 diabetic. In addition, we examined BMI across the three categories of diabetes status
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(Figure 5). This revealed that those with unknown diabetes had the lowest BMI (mean 20.9, SD 3.7) which was largely consistent with the non-diabetic group (mean 21.1, SD 3.9) and substantially lower than those with self-reported diabetes (mean 24.4, SD 4.9). Finally, we examined interactions between socioeconomic variables (caste, education, wealth) and diabetes by residential location. Tests of these interactions were not statistically significant (P=0.20 for caste; P=0.72 for education; P=0.66 for wealth).

DISCUSSION

In this study, we have three key findings. First, measures of SES were positively associated with self-reported diabetes in the NFHS-3. Although the observed effects of caste and education were largely attenuated in fully adjusted models, the effect of household wealth remained positive, graded and statistically significant even after controlling for BMI. Second, we observed a large variation in the prevalence of diabetes between local areas and States in India. A few Southern and northeastern states were associated with a higher risk for reporting diabetes while several northern and central states were at lower risk after adjusting for individual characteristics and place of residence. Lastly, the observed association between household wealth and self-reported diabetes was consistent, positive, and statistically significant across a majority of states in India.

There are a few limitations to our study. First, the outcome was defined on the basis of self-reported diabetes, although interviews were conducted in person using a standardized instrument. Previous research has shown good agreement for self-reported diabetes when compared to medical records in a US population [51], and that that self-

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3 reported health conditions demonstrate the expected relationship with SES in India.[52]
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5 In addition, our sensitivity analyses considering respondents who reported “unknown” for
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7 diabetes status were nearly identical to the main analyses. We did find, however,
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9 evidence that higher SES groups were less likely to report “did not know” as compared to
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11 “no”, which has been suggested previously on studies using self-reports of diabetes status
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13 in India.[6] However, the unknown group was more similar in terms of BMI, education,
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15 and wealth to the non-diabetic rather than diabetic group. In addition, our findings of
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17 positive SES-diabetes associations were consistent with several studies identified in our
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19 literature review which used blood glucose measurements for the assessment of diabetes
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21 status (summarized in Table 1). Lastly, although our sample was relatively young (<55 y
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23 for men and <50 y for women) it is representative of the young population of profile of
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25 India; 84% of the Indian adult population (18-69 y) and 47% of the total Indian
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27 population at all ages fall within the ages covered by this study.[53] Our study does
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29 exclude approximately 12% of the Indian population (women over the age of 50 and men
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31 over the age of 55) due to the sample design of the NFHS. The prevalence of diabetes
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33 increases with age and whether a similar SES-diabetes relationship exists among middle
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35 and older age groups in all parts India is not clear, although our findings are consistent
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37 with previous studies which have included older ages.
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46 Our findings of positive SES-diabetes associations are consistent with previous
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48 studies done in different parts of India. For example, an analysis of rural participants
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50 from the Indian Migration Study, which sampled primarily from four large states in the
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52 north, centre, and south of India [17], identified a positive SES-diabetes gradient among
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54 men (8.0% prevalence in high SES group v 1.8% in low SES group), and a weaker
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3 positive SES-diabetes association that was not statistically significant among women
4 (5.1% v 3.9%). In addition, a study done in an urban setting in Madras (Chennai) found
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6 an odds ratio for diabetes of 2.2 (95% confidence interval [CI]: 1.7-2.7) for high v low
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positive SES-diabetes association that was not statistically significant among women (5.1% v 3.9%). In addition, a study done in an urban setting in Madras (Chennai) found an odds ratio for diabetes of 2.2 (95% confidence interval [CI]: 1.7-2.7) for high v low SES groups.[11] One larger study conducted in urban and rural surveillance locations in Northern, Southern, Eastern, and Western/Central India identified an odds ratio of 3.0 (95% CI: 2.5-3.7) for self-reported diabetes for those with graduate level education versus those without formal schooling.[6] Importantly, these studies were limited to selected geographical areas or cities in India. Our study has added to this literature using a national population health survey with good coverage in rural areas across India.

Previous research in India has identified a strong positive relation between SES and BMI among women and men in India. [54-56] These studies are important because they have used similar markers of SES in the Indian context along with an objectively defined outcome (height and weight were measured in NFHS and not self-reported). BMI (along with other measures of body weight) is an important risk factor for the development of type 2 diabetes. [48 50 57] Therefore, the consistency of our findings of a positive SES-diabetes association after controlling for BMI is encouraging. If BMI is part of the causal pathway between SES and diabetes, attenuation in the effect size for markers of SES would be expected. The graded and positive relation between household wealth and diabetes after accounting for BMI suggests that there are additional effects of household wealth on diabetes that are not mediated by BMI. The effects of social caste and education were largely attenuated after the inclusion of household wealth and prior to the inclusion of BMI. Household wealth was the strongest socioeconomic factor associated with self-reported diabetes, suggesting that social and behavioural changes

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3 associated with diabetes in India may be more closely related to increasing wealth and/or
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5 standard of living than educational attainment.
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8 When compared to other studies in India, the overall prevalence of diabetes in the
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10 NFHS-3 was not high. This may have resulted from a combination of using self-reports
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12 of diabetes, the younger age of the NFHS-3 target population, and sampling from the
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14 general population which included a high proportion of respondents in rural areas.
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17 Among individuals over 30 years of age, the prevalence was 2.5% (3.0 % in men and
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19 2.2% in women). Other studies using in rural India using similar age groups and blood
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21 measurements have reported diabetes prevalence of 4% and a study from rural Andhra
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23 Pradesh found a prevalence of 12% based on combination self-report and blood
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25 measurements.[17 58]
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29 The current national estimate for diabetes prevalence in India is about 7% of the
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31 adult population aged 20-79. This estimate is based on 3 relatively recent and larger
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33 scale studies using a combination of oral glucose tolerance testing and self-reports of
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35 diabetes.[4-6] There continues to be considerable uncertainty in estimates of diabetes for
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37 the whole of India due to the limited study locations (with a focus on urban areas), wide
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39 variation in survey sampling methodology, differences in diabetes diagnostic criteria, and
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41 age groups studied. These differences in study design have hindered direct comparison
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43 of the prevalence between studies, across regions and over time. The NFHS-3 provides
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45 an important benchmark because it is the first nationally-representative survey of
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47 diabetes in India. Even if the prevalence estimates of diabetes have been underestimated
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49 in the NFHS-3, the observed SES-diabetes associations are plausible and important.
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3 markers, which may be a key determinant of diabetes. Further large-scale population-
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5 based surveys can be strengthened by using simple finger-prick blood glucose
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7 measurements in addition to self-reports.
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11 There has been considerable concern over the rising prevalence of diabetes in
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13 India, especially with studies on migrant Indian populations suggesting that South Asians
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15 may be more susceptible to the disease. In light of current findings, it appears that, at
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17 present, the more well-off segments of the Indian population are at greatest risk. This
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19 poses concerns on how to appropriately balance priorities to address the disease burden
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21 that afflicts the non poor versus the poor in the context of India where greater than 40%
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23 of the population continue to live in extreme poverty on less than \$1.25 per day.[59]
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31 SVS and DJC planned the study. DJC conducted statistical analyses and drafted the
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33 manuscript with supervision from SVS. Both authors participated in interpretation of the
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35 results and critical revisions of the manuscript.
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39 The NFHS data are available through the Measure DHS project at www.measuredhs.com.
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Table 1 Overview of studies reporting prevalence of type-2 diabetes by markers of socioeconomic status (SES) and the association between increasing SES and diabetes in India

Author	Study period	Coverage	Setting	Age	Sample size	Diabetes assessment	SES marker	Gender	Diabetes prevalence: low SES (l); high SES (h)	SES-diabetes association: Odds ratio (95% confidence interval) for high SES vs low SES
Singh[7]	1994	Local	Rural	25-64	1769	blood glucose	Composite	Male	0.9% (l); 6.1% (h)*	-
								Female	0.9% (l); 6.9% (h)*	-
Singh[8]	1994	Local	Rural	25-64	1806	blood glucose	Composite	Male	2.5% (l); 8.6% (h)*	2.03 (1.86-2.51)*
								Female	1.2% (l); 6.9% (h)*	1.97 (1.67-2.36)*
Singh[9]	1994	Local	Combined	25-64	3575	blood glucose	Composite	Male	-	4.07 (1.89-10.01)* (Urban)
								-	3.75 (1.37-12.78)* (Rural)	
								Female	-	1.48 (0.64-4.00) (Urban)
								-	2.55 (0.91-8.83) (Rural)	
Singh[10]	1998	Regional	Urban	25-64	3257	blood glucose	Composite	Female	0.5% (l); 4.8% (h)*	-
Ramachandran[4]	2000	Regional	Urban	20+	11216	blood glucose	Income	Combined	12.5% (l); 21.6% (h)*	1.43 (1.30-1.57)*; 1.16 (1.05-1.30)*
Ramachandran[11]	1999-2000	Local	Urban	40+	2383	blood glucose, drug treatment	Income	Combined	12.6% (l); 25.5% (h)*	2.15 (1.70-2.72)
Gupta[12]	1999-2001	Local	Urban	20+	1123	self-report	Education	Male	6.8% (l); 7.9% (h)	-
								Female	6.6% (l); 8.3% (h)	-

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5	Reddy[13]	2002-2003	Regional	Urban	20-69	19973	blood glucose, drug treatment	Education	Male	7.6% (l); 8.4% (h)	1.11 (0.71-1.67)	
6									Female	11.2% (l); 4.2% (h)*	0.36 (0.23-0.56)*	
7												
8												
9	Mohan[6]	2003-2005	Regional	Combined	15-64	44523	self-report	Education	Combined	3.4% (l); 5.6% (h)*	3.02 (2.45-3.71)*	
10												
11	Ajay[14]	2002-2003	Regional	Urban	20-69	10930	blood glucose, drug treatment	Education	Combined	11.6% (l); 6.9% (h)*	0.69 (0.54-0.89)*	
12												
13	Vijayakumar[15]	2007	Local	Rural	18+	1990	blood glucose, self-report	Social caste	Combined	5.9% (l); 17.4% (h)	-	
14								Wealth	Combined		1.43 (1.04-1.95)*	
15												
16	Gupta[16]	1999-2003	Local	Urban	20-59	1289	blood glucose, self-report	Education	Male	8.0% (l); 18.8% (h)*	-	
17									Female	6.0% (l); 34.7% (h)*	-	
18									Combined	6.9% (l); 26.4% (h)*	-	
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24	Kinra[17]	2005-2007	Regional	Rural	20-69	1983	blood glucose, self-report	Wealth	Male	1.8% (l); 8.0% (h)*	-	
25									Female	3.9% (l); 5.1% (h)	-	
26												
27												
28	Samuel[18]	1969-2002	Regional	Urban	26-32	2218	blood glucose†, drug treatment	Wealth	Male	26.2% (l); 31.9% (h)* (Urban)	-	
29										10.9% (l); 31.8% (h) (Rural)	-	
30										12.1% (l); 30.3% (h)* (Urban)	-	
31										16.1% (l); 32.1% (h)* (Rural)	-	
32												
33				Rural					Female			
34									Combined	-	2.8 (1.9-4.1)*	
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36				Combined					Male	15.0% (l); 34.7% (h) (Urban)	-	
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									25.7% (l); 19.7% (h)	-	
			Rural					Female	31.5% (l); 32.2% (h)*	-	
									(Urban)	-	
									19.1% (l); 50.0% (h)	-	
			Combined					Combined	-	1.0 (0.6-1.6)	
Zaman[19]	2005	Regional	Rural	30+	4535	blood glucose, self-report		Income	Male	16.2% (l); 21.2% (h)*	-
									Female	12.1% (l); 15.0% (h)*	-
								Education	Male	12.4% (l); 20.1% (h)*	-
									Female	12.8% (l); 13.1% (h)	-

Notes: Socioeconomic status (SES) markers defined as education, household wealth, social caste, or a composite of 2 or more measures; *P<0.05; - indicates not reported; †includes impaired glucose tolerance and impaired fasting glucose

Table 2 Characteristics of survey participants and frequency distribution of self-reported diabetes in India, males and females from the 3rd National Family Health Survey

	Self-reported diabetes		Total
	<i>n</i>	%	<i>n</i>
Participants	2439	1.5	168135
Residence			
Rural	818	1.0	86013
Urban	1621	2.0	82122
Age group			
18-29 y	266	0.3	76174
30-39 y	602	1.2	51132
40-49 y	1238	3.4	36402
50-54 y	333	7.5	4427
Gender			
Male	1144	1.8	65255
Female	1295	1.3	102880
Marital status			
Single	132	0.3	38078
Married	2165	1.8	123457
Widowed	108	2.5	4320
Divorced or separated	34	1.5	2280
Religion			
Hindu	1775	1.4	123411
Muslim	340	1.6	21510
Christian	213	1.4	14779
Sikh	49	1.5	3236
Buddhist	34	1.4	2451
Other	28	1.0	2748
Social Caste			
Other caste	1026	1.8	56063
Scheduled caste	349	1.3	27677
Scheduled tribe	167	0.8	21372
Other backward class	781	1.4	55641
No caste	116	1.6	7382
Education			
No education	464	1.0	44856
Primary	358	1.4	24969

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3	Secondary	1166	1.6	74715
4	Higher	451	1.9	23595
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7	Household wealth			
8	Poorest	77	0.4	17252
9	2 nd quintile	175	0.8	22948
10	3 rd quintile	278	0.9	32070
11	4 th quintile	573	1.4	42091
12	Richest	1336	2.5	53774
13				
14				
15	Body mass index (kg/m ²)			
16	<18.5	243	0.6	42128
17	18.5-22.9	703	0.9	74089
18	23-27.4	833	2.7	31217
19	27.5+	547	4.8	11502
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Table 3 Associations between socioeconomic status and self-reported diabetes in India; 3rd National family health survey, 2005-6

Variable	Models 1-3		Model 4		Model 5	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Social Caste						
Other caste	1.00		1.00		1.00	
Scheduled caste	0.81	(0.71 - 0.94)	1.05	(0.91 - 1.21)	1.07	(0.93 - 1.24)
Scheduled tribe	0.57	(0.46 - 0.70)	0.72	(0.58 - 0.90)	0.73	(0.57 - 0.92)
Other backward caste	0.84	(0.75 - 0.94)	0.95	(0.85 - 1.07)	0.96	(0.86 - 1.08)
No caste	0.89	(0.71 - 1.11)	0.94	(0.75 - 1.17)	0.95	(0.76 - 1.20)
Wealth						
Poorest	1.00		1.00		1.00	
2nd quintile	1.59	(1.20 - 2.12)	1.57	(1.21 - 2.07)	1.49	(1.14 - 1.96)
3rd quintile	1.63	(1.23 - 2.16)	1.55	(1.21 - 2.02)	1.39	(1.07 - 1.81)
4th quintile	2.42	(1.85 - 3.17)	2.25	(1.76 - 2.92)	1.79	(1.40 - 2.34)
Richest	4.04	(3.08 - 5.30)	3.65	(2.83 - 4.78)	2.58	(1.99 - 3.40)
Education						
No education	1.00		1.00		1.00	
Primary	1.23	(1.06 - 1.43)	1.06	(0.91 - 1.22)	1.00	(0.86 - 1.17)
Secondary	1.68	(1.49 - 1.90)	1.18	(1.04 - 1.35)	1.12	(0.98 - 1.28)
Higher	1.87	(1.61 - 2.18)	1.12	(0.95 - 1.32)	1.01	(0.86 - 1.20)
Body mass index (kg/m²)						
<18.5					1.00	
18.5-22.9					1.25	(1.08 - 1.46)
23-27.4					2.08	(1.79 - 2.44)
27.5+					2.98	(2.51 - 3.54)

Notes: In models 1-3 one SES marker (social caste, household wealth, education) was modelled at a time while adjusting for age, gender, religion, and place of residence. In model 4, all SES markers were included along with covariates from models 1-3. In model 5, BMI was included with markers of SES and covariates from model 4.

Table 4 Variance in self-reported diabetes status between local areas and states in India; expressed as percentage of the contribution to the total variance in diabetes

	Age & gender adjusted*			Fully adjusted**		
	Variance	SE	%	Variance	SE	%
States	0.231	0.076	5.9	0.204	0.068	5.4
Local areas	0.425	0.043	10.8	0.240	0.041	6.4

Notes:

*Multilevel model adjusted for age and gender only

**Multilevel model fully adjusted for age, gender, marital status, religion, social caste, household wealth, education, body mass index, and place of residence

FIGURE LEGENDS

Figure 1 Flow diagram showing exclusions and final sample sizes, 2005-6 National Family Health Survey (NFHS)

Notes for figure 1: *2,333 individuals reported unknown diabetes status; in 40 individuals diabetes status was not reported/missing. Of the 2,333 individuals who reported unknown diabetes status, 2,210 (94.7%) had complete data for BMI and were included in sensitivity analyses.

**Analyses involving body mass index (BMI) as an independent variable were restricted to 158,936 individuals

Figure 2 State level prevalence of self-reported diabetes in India for men aged 18-54 (left) and women aged 18-49 (right). Darker colours indicate higher prevalence.

Notes for figure 2: State name abbreviations: AP Andhra Pradesh; AR Arunachal Pradesh; AS Assam; BR Bihar; CT Chhattisgarh; DL Delhi; GA Goa; GJ Gujarat; HR Haryana; HP Himachal Pradesh; JK Jammu & Kashmir; JH Jharkhand; KA Karnataka; KL Kerala; MP Madhya Pradesh; MH Maharashtra; MN Manipur; ML Meghalaya; MZ Mizoram; NL Nagaland; OR Orissa; PB Punjab; RJ Rajasthan; SK Sikkim; TN Tamil Nadu; TR Tripura; UP Uttar Pradesh; UK Uttarakhand (Uttaranchal); WB West Bengal

Figure 3 Odds ratios for self-reported diabetes by state of residence in India

Notes for figure 3: horizontal lines are 95% credible intervals; adjusted for age, gender, marital status, religion, social caste, household wealth, education, body mass index and place of residence.

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3 **Figure 4** Odds ratio (OR) for self-reported diabetes for a one-quintile increase in
4 household wealth for men (aged 18-54) and women (aged 18-49) in India and 29 states
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7 Notes for figure 4: Adjusted for age, gender, marital status, religion, social caste,
8 education, body mass index and place of residence.
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10 **Figure 5** Mean body mass index across three possible responses for self-reported
11 diabetes.
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14 Notes for figure 5: Vertical lines represent 95% confidence intervals. Body mass index
15 (in kg/m²) calculated from measured height and weight values. Horizontal line represents
16 overall mean body mass index (21.2 kg/m², SD 3.9).
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SUPPLEMENTAL MATERIAL

Supplemental Table 1 Associations between socioeconomic status and self-reported diabetes in India from models restricted to male and female samples; 3rd National family health survey 2005-6

Variable	Men aged 18-54						Women aged 18-49											
	Models 1-3			Model 4			Model 5			Models 1-3			Model 4			Model 5		
	O	R	95% CI	O	R	95% CI	O	R	95% CI	O	R	95% CI	O	R	95% CI	O	R	95% CI
Social Caste	1.0			1.0			1.0			1.0			1.0			1.0		
Other caste	0			0			0			0			0			0		
Scheduled caste	0.8	(0.68	1.0	1.1	(0.92	1.3	1.2	(0.96	1.4	0.7	(0.64	0.9	0.9	(0.78	1.1	0.9	(0.79	1.1
Scheduled tribe	4	-	3)	4	-	9)	0	-	8)	7	-	3)	5	-	4)	7	-	6)
Other backward caste	0.5	(0.40	0.7	0.7	(0.52	1.0	0.7	(0.56	1.0	0.5	(0.39	0.7	0.6	(0.48	0.8	0.6	(0.48	0.8
No caste	5	-	5)	3	-	0)	8	-	7)	4	-	1)	5	-	7)	4	-	7)
Other backward caste	0.8	(0.74	1.0	1.0	(0.86	1.1	1.0	(0.88	1.2	0.7	(0.67	0.9	0.8	(0.74	1.0	0.8	(0.75	1.0
No caste	6	-	0)	1	-	9)	4	-	3)	8	-	1)	6	-	1)	7	-	2)
No caste	0.9	(0.62	1.3	0.9	(0.65	1.4	1.0	(0.71	1.5	0.8	(0.66	1.1	0.9	(0.68	1.2	0.9	(0.67	1.2
No caste	2	-	7)	6	-	0)	4	-	2)	7	-	6)	0	-	1)	1	-	2)
Wealth	1.0			1.0			1.0			1.0			1.0			1.0		
Poorest	0			0			0			0			0			0		
2nd quintile	1.4	(0.97	2.1	1.3	(0.94	1.9	1.3	(0.89	1.8	1.7	(1.17	2.4	1.6	(1.15	2.4	1.6	(1.18	2.5
3rd quintile	0	-	1)	5	-	7)	2	-	8)	2	-	6)	6	-	4)	9	-	2)
4th quintile	1.4	(1.03	2.1	1.3	(0.95	1.9	1.2	(0.88	1.8	1.7	(1.17	2.5	1.6	(1.10	2.2	1.4	(1.07	2.2
Richest	6	-	5)	6	-	6)	9	-	0)	3	-	2)	0	-	6)	8	-	5)
Richest	2.1	(1.51	3.1	1.8	(1.34	2.6	1.6	(1.14	2.2	2.6	(1.79	3.8	2.3	(1.64	3.3	1.8	(1.38	2.8
No education	0	-	0)	7	-	2)	5	-	8)	6	-	7)	4	-	2)	9	-	3)
Primary	4.5	(3.22	6.8	3.8	(2.73	5.3	3.0	(2.05	4.2	3.6	(2.42	5.4	3.1	(2.19	4.4	2.2	(1.62	3.3
Primary	5	-	1)	2	-	7)	4	-	7)	7	-	1)	6	-	7)	4	-	2)
Education	1.0			1.0			1.0			1.0			1.0			1.0		
No education	0			0			0			0			0			0		
Primary	1.1	(0.86	1.3	0.9	(0.75	1.2	0.9	(0.70	1.2	1.3	(1.16	1.6	1.1	(0.98	1.4	1.1	(0.92	1.3

	0	-	8)	6	-	1)	2	-	0)	9	-	7)	7	-	0)	1	-	3)
	1.6	(1.37	2.0	1.1	(0.90	1.4	1.0	(0.85	1.3	1.7	(1.52	2.0	1.2	(1.08	1.5	1.2	(1.02	1.4
Secondary	6	-	1)	3	-	4)	7	-	6)	6	-	2)	8	-	0)	1	-	3)
	2.3	(1.87	2.9	1.2	(0.98	1.7	1.1	(0.86	1.4	1.4	(1.12	1.7	0.9	(0.72	1.1	0.8	(0.66	1.0
Higher	6	-	2)	7	-	0)	3	-	8)	0	-	3)	1	-	5)	5	-	8)
Body mass index (kg/m ²)																		
<18							1.0									1.0		
							0									0		
18.5-22.9							1.2	(0.99	1.5							1.2	(1.01	1.5
							5	-	5)							4	-	3)
23-27.4							2.0	(1.59	2.5							2.1	(1.75	2.6
							0	-	0)							2	-	8)
27.5+							2.1	(1.65	2.8							3.5	(2.89	4.5
							5	-	6)							8	-	6)

Notes: OR odds ratio; In models 1-3 one SES marker (social caste, household wealth, education) was modelled at a time while adjusting for age, gender, religion, and place of residence. In model 4, all SES markers were included along with covariates from models 1-3. In model 5, BMI was included with markers of SES and covariates from model 4.

Supplemental Table 2 Odds ratio (OR) for self-reported diabetes for a one-quintile increase in household wealth for men (aged 18-54) and women (aged 18-49) in India and 29 states

State	<i>n</i>	Self-reported diabetes	
		Wealth OR	95% CI*
India	158,936	1.31	(1.20 - 1.42)
Jammu and Kashmir	3,383	1.55	(1.21 - 1.98)
Maharashtra	14,053	1.51	(1.27 - 1.78)
Orissa	4,838	1.50	(1.24 - 1.81)
Arunachal Pradesh	1,798	1.49	(1.14 - 1.94)
Uttar Pradesh	17,555	1.47	(1.28 - 1.70)
Sikkim	2,406	1.46	(1.11 - 1.92)
Madhya Pradesh	7,756	1.43	(1.19 - 1.71)
Assam	3,904	1.43	(1.15 - 1.77)
Uttaranchal	3,120	1.42	(1.12 - 1.81)
Punjab	4,134	1.41	(1.10 - 1.81)
Mizoram	2,089	1.40	(1.07 - 1.85)
Karnataka	9,049	1.40	(1.19 - 1.64)
Chhattisgarh	4,246	1.36	(1.14 - 1.64)
Delhi	3,026	1.35	(1.05 - 1.73)
Rajasthan	4,433	1.33	(1.03 - 1.71)
Meghalaya	2,135	1.29	(1.03 - 1.63)
Jharkhand	3,044	1.29	(1.06 - 1.57)
Tamil Nadu	10,106	1.28	(1.11 - 1.48)
Andhra Pradesh	11,824	1.25	(1.09 - 1.45)
Himachal Pradesh	3,563	1.25	(0.97 - 1.61)
Gujarat	4,322	1.25	(1.00 - 1.56)
Goa	3,883	1.20	(0.98 - 1.48)
Nagaland	6,350	1.19	(0.99 - 1.44)
Tripura	2,089	1.18	(0.96 - 1.45)
Manipur	6,941	1.14	(0.95 - 1.37)
Haryana	3,173	1.11	(0.90 - 1.38)
Bihar	3,882	1.10	(0.93 - 1.30)
Kerala	4,018	1.10	(0.89 - 1.35)
West Bengal	7,816	0.95	(0.83 - 1.09)

Notes: Odds ratios (OR) and 95% credible intervals (CI) adjusted for age, gender, marital status, religion, social caste, education, body mass index and place of residence.

Supplemental Table 3 Associations between socioeconomic status and body mass index for self-reported diabetics and those with unknown diabetes status compared to self-reported non-diabetics using a multilevel multinomial regression model.

Variable	Self-reported diabetes		Unknown diabetes status	
	Odds ratio	95% CI*	Odds ratio	95% CI
Social Caste				
Other caste	1.00		1.00	
Scheduled caste	1.07	(0.93 - 1.24)	1.13	(0.96 - 1.31)
Scheduled tribe	0.73	(0.58 - 0.91)	1.52	(1.25 - 1.84)
Other backward caste	0.96	(0.86 - 1.08)	1.07	(0.93 - 1.23)
No caste	0.95	(0.75 - 1.18)	0.76	(0.58 - 0.99)
Wealth				
Poorest	1.00		1.00	
2nd quintile	1.51	(1.14 - 2.03)	0.90	(0.77 - 1.05)
3rd quintile	1.41	(1.07 - 1.89)	0.86	(0.73 - 1.01)
4th quintile	1.82	(1.38 - 2.44)	0.82	(0.68 - 0.98)
Richest	2.63	(1.97 - 3.56)	0.64	(0.51 - 0.79)
Education				
No education	1.00		1.00	
Primary	1.00	(0.87 - 1.17)	0.86	(0.76 - 0.99)
Secondary	1.12	(0.98 - 1.28)	0.71	(0.63 - 0.81)
Higher	1.01	(0.85 - 1.21)	0.45	(0.36 - 0.57)
Body mass index				
<18.5	1.00		1.00	
18.5-22.9	1.26	(1.08 - 1.46)	1.03	(0.93 - 1.15)
23-27.4	2.09	(1.79 - 2.45)	1.17	(1.01 - 1.36)
27.5+	2.99	(2.52 - 3.55)	1.33	(1.06 - 1.66)

Notes: model adjusted for age, gender, religion, marital status, place of residence
*95% credible interval

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8 **Title** Association between socioeconomic status and self-reported diabetes in India: a
9 cross-sectional multilevel analysis
10

11 **Authors and affiliation**

12 Daniel J Corsi, MSc, Population Health Research Institute, McMaster University,
13
14 Hamilton, ON, Canada
15

16 SV Subramanian, PhD, Professor of Population Health and Geography,
17
18 Department of Society, Human Development, and Health, Harvard School of Public
19
20 Health, Boston, MA, USA
21
22

23 **Corresponding author details**

24
25 Professor S V Subramanian, Harvard School of Public Health, 677 Huntington Avenue,
26
27 Boston MA 02115, USA; Tel: 617-432-6299; Fax: 617-432-3123; Email:

28
29 svsubram@hsph.harvard.edu
30

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ABSTRACT

Objectives To quantify the association between socioeconomic status (SES) and type-2 diabetes in India

Design Nationally representative cross-sectional household survey

Setting Urban and rural areas across 29 states in India

Participants 168,135 survey respondents aged 18-49 y (women) and 18-54 y (men)

Primary outcome measure Self-reported diabetes status

Results Markers of SES were social caste, ~~education, and~~ household wealth, ~~and~~ education. The overall prevalence of self-reported diabetes was 1.5%; this increased to 1.9% and 2.5% for those with the highest levels of education and household wealth, respectively. In ~~adjusted~~ multilevel logistic ~~regression models-~~ (adjusted for age, gender, religion, marital status, and place of residence) ~~regression models~~, education (odds ratio 1.87 for higher education vs no education) and household wealth (odds ratio 4.04 for richest quintile vs poorest) were positively related to self-reported diabetes ($P < 0.0001$). In a fully adjusted model including all socioeconomic variables and body mass index (BMI), household wealth emerged as positive and statistically significant with an the odds ratio for self-reported diabetes ~~was of~~ 2.58 (95% credible interval [CI]: 1.99-3.40) for the richest quintile of household wealth versus the poorest. Nationally in India a one-quintile increase in household wealth was associated with an odds ratio of 1.31 (95% CI: 1.20-1.42) for self-reported diabetes. This association was consistent across states with the relationship found to be positive in 97% (28 of 29 states) and statistically significant in 69% (20 of 29).

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8 **Conclusions** We found that the highest socioeconomic status groups in India appear to be
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10 at greatest risk for type-2 diabetes. This raises important policy implications for
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12 addressing the disease burdens among the poor versus those among the non poor in the
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14 context of India, where ~~nearly greater than half of the 40 percent of the~~ population is
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16 living in poverty.
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ARTICLE SUMMARY

Article Focus

- The relationship between socioeconomic factors and type-2 diabetes has not been previously studied for the whole of India [and across states](#)
- Our objective was to investigate associations between measures of socioeconomic status (defined as social caste, education, household wealth) and self-reported diabetes status in India
- In addition we explored geographic variation in [diabetes-the prevalence of diabetes](#) between states and local areas in India [and between-state variability in the SES-diabetes relationship](#)

Key messages

- The highest socioeconomic groups appear to be at greatest risk for diabetes in India; [with the strength of the association consistent in size and magnitude across states](#)
- ~~In addition, t~~There is substantial geographic heterogeneity in the prevalence of diabetes
- These findings raise important policy implications for in addressing the disease burdens among the poor versus those among the non poor in the context of India, where nearly half of the population is living in poverty.

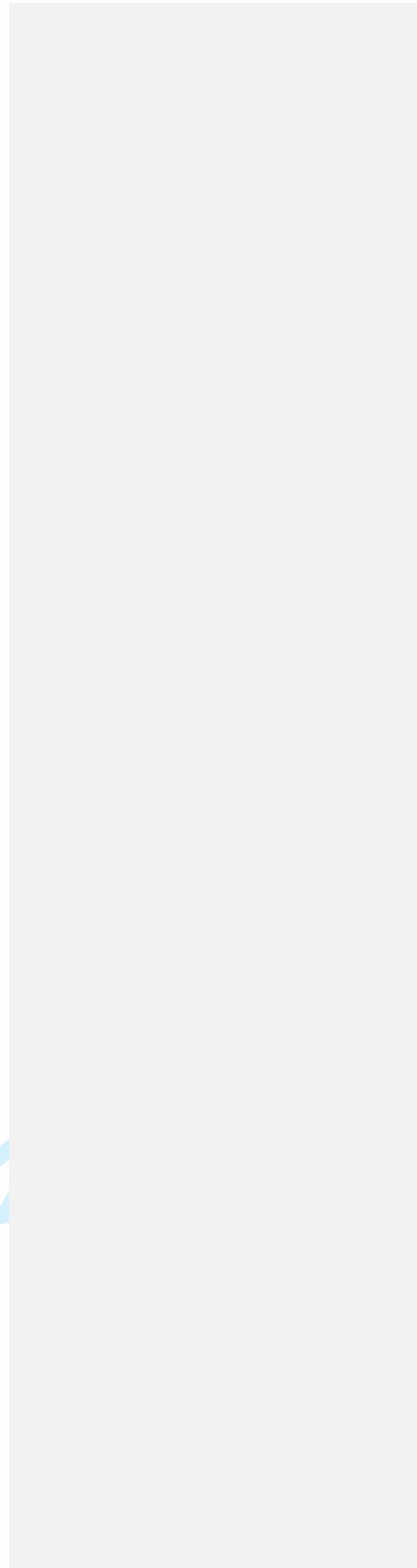
Strengths and Limitations

- The key strength of this study is the use of a large, nationally-representative survey to assess the socioeconomic and geographic patterning of diabetes across

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all of India. Limitations include the relatively younger age of the sample and assessment of diabetes status on the basis of self-reports.

For peer review only



INTRODUCTION

The prevalence of type-2 diabetes in India has been investigated in numerous population based surveys conducted across a range of settings since the 1970s.[1-6] Despite multiple prevalence studies, few no nationally representative studies exist which have considered the association between socioeconomic status (SES) and type-2 diabetes in India. In a review of 15 existing studies which have reported the prevalence of type-2 diabetes by SES and/or associations between SES and type-2 diabetes, all were found to have been based on local or regional samples and a majority were done in urban areas[4 6-19] (Table 1). ~~Recently, it~~ has been suggested ~~that that the prevalence of type-2 diabetes and other cardiovascular disease risk factors may increasingly become concentrated among low SES groups in India~~[20] ~~and other “poor people are disproportionately affected” by diabetes and other non-communicable diseases in low- and middle-income countries~~ [21], ~~although to date the the empirical evidence in the from Indian context in support of this hypothesis remains limited.~~ The majority of Sstudies reviewed in table 1 among populations from a few geographic regions in India have provided some evidence of a positive SES diabetes association between SES (defined as education, household wealth, social caste, or a composite of 2 or more markers) and diabetes among populations from selected geographic regions in India [6 11 17]; however the strength and consistency of this association across the whole of India ~~remains uncertain~~ has not previously been assessed.

Type-2 diabetes is the most common form of diabetes globally, accounting for greater than 85% of cases.[22] The incidence of type-2 diabetes is related to genetic and non-genetic components, with the latter being greatly influenced by modifiable risk

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8 factors such as obesity, diets low in fibre and high in trans fat, and physical
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10 inactivity.[23-24] ~~These lifestyle behaviours themselves~~ are strongly patterned by SES
11 [25], and may be mediators on the causal pathway between SES and the onset of type-2
12 diabetes.[26] In high income countries, the SES-diabetes relationship appears to be
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14 negative, with the poor at greatest risk. For example, strong associations have been
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16 observed between poverty, low education and type-2 diabetes among African American
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18 women [27-28], and among White women and men in the United States.[29] Similarly, a
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20 study from Canada described an inversely graded SES-diabetes association with an odds
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22 ratio of 1.9 for men (95% CI: 1.6-2.4) and 2.8 (95% CI: 2.2-3.4) for women for the
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24 lowest versus highest income groups.[30] A recent meta-analysis of 23 ~~epidemiological~~
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26 ~~case-control and cohort~~ studies and 43 measures of SES-diabetes association revealed an
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28 overall increased risk for type-2 diabetes for low SES groups based on education,
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30 occupation, and income.[31] The strength of the association, however, was less
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32 consistent in low and middle income countries (LMICs), and few studies have been
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34 conducted in these countries.
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37 Concern has been raised over the anticipated rapid increase in type-2 diabetes
38 prevalence in India.[32-33] Evidence on the secular increases in diabetes prevalence in
39 India, however, have been limited to urban areas of Southern India[4 34-35], and have
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41 focused on the mean rates of diabetes rather than how it is distributed in the population.
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45 In this paper we ~~address the need to comprehensively investigate the socioeconomic and~~
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47 ~~geographic distribution of type-2 diabetes in the Indian population using a large-scale~~
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49 ~~nationally representative survey. Specifically, we~~ investigate the SES-diabetes ~~relation~~
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51 ~~association through the SES markers of social caste, household wealth, and education.~~ ~~in~~
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8 ~~India using a large-scale nationally representative survey.~~ In addition, we investigate the
9 ~~geographical-geographic~~ distribution of ~~the prevalence of~~ diabetes ~~at the state and local~~
10 ~~area levels in India~~ across states and local areas along with variability in the SES-diabetes
11 ~~association across states.~~
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18 METHODS

19 Data source

20 We use data from the 3rd National Family Health Survey (NFHS), conducted in 29
21 states in India between November 2005 and August 2006.[36] NFHS-3 is a major
22 national health survey in India which collected information on a range of indicators
23 including reproductive health, nutritional status of adults and children, utilization of
24 health care services, and blood testing for HIV prevalence. NFHS-3 covered all states in
25 India, which comprise nearly 99% of the population, but excluded Union Territories. The
26 survey was designed to provide estimates of key indicators (except HIV prevalence) for
27 each state by urban and rural areas.
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37 Survey design

38 A uniform multistage sampling strategy was adopted in all states, with separate
39 sampling in urban and rural areas.[37-38] In rural areas, a two stage sample was carried
40 out using a list of villages from the 2001 census as the sampling frame. In the first stage,
41 a stratified sample of villages was drawn with probability proportional to the size of the
42 village. In the second stage, a random selection of households was drawn in each village
43 from a complete list of households compiled during field visits carried out in each
44 sampled village. In urban areas, a similar procedure was implemented beginning with a
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8 stratified random sample of municipal wards based on the 2001 census. Next, one census
9 enumeration block (150-200 households) was selected from within wards using
10 probability proportional to size. Finally, as in rural areas, field enumerators undertook a
11 household listing operation in selected blocks and a random sample of households was
12 made. In both rural and urban areas, 30 households were targeted for selection in each of
13 the sampled units. The overall household response rate for NFHS-3 was 98%.^[36]

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20 All ~~ever married and never married~~ women aged 15-49 in selected households
21 were invited to participate in the survey. In 22 states, men aged 15-54 in a random
22 subsample of households drawn from each PSU (about 6 households per PSU)~~subsample~~
23 of households were eligible for the men's survey. In the remaining seven states (Andhra
24 Pradesh, Karnataka, Maharashtra, Manipur, Tamil Nadu, Uttar Pradesh, and Nagaland)
25 all-eligible men all in selected households were invited to participate. The additional men
26 recruited in these states was for the purpose of HIV testing to provide reliable state level
27 estimates of HIV prevalence in certain states. Interviews were conducted in 1 of the 18
28 Indian languages in the respondent's home and the response rates were 95% for women
29 and 87% for men.^[36] During interviews, the weights and heights of survey respondents
30 were measured by trained field technicians using standardized measuring equipment
31 designed for survey settings.^[39]

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43 In total NFHS-3 collected information from 109,041 households, 124,385 women
44 from age 15 to 49 years of age, and 74,369 men from age 15 to 54 years of age.^[24]
45 We restricted our analyses to adults aged 18 years and older and non-pregnant women
46 (n=171,207). Respondents who did not report or know their diabetes status (n= 2,373~~85~~)
47 or with incomplete information for any of the independent variables considered in the
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analysis (marital status, religion, caste, education, household wealth) were excluded (n=69987). ~~Main –~~Analyses were conducted on a sample of 168,135 respondents, (65,255 men and 102,880 women). Additional analyses considering body mass index (BMI) were restricted to a sample of 158,936 due to missing and/or implausible values for height and/or weight. Figure 1 provides a flow diagram detailing the NFHS sample, exclusions, and final analytic sample sizes.

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Outcome and independent variables

The primary outcome was diabetes, assessed on the basis of self-reports by survey respondents. ~~Markers of S~~socioeconomic status ~~was measured by~~were social caste, ~~education, and~~household wealth, ~~and education~~. Social caste was reported by the household head. The categories were Other Caste, Scheduled caste, Scheduled tribe, Other Backward Class, and No Caste. Other Caste is a heterogeneous group that is traditionally viewed as having higher social status. ~~–~~Scheduled castes and scheduled tribes are considered lower, socially marginalized groups in India.[40] ~~Education was specified as no education, primary, secondary, or higher education.~~ Household wealth was defined by an index based on indicators of asset ownership and housing characteristics.[41] This index has been developed and validated in a number of countries to be a robust measure of wealth and has been found to be consistent with measures of income and expenditure.[42] Briefly, the measure was constructed as follows. Information on 33 indicators of housing characteristics (e.g., type of windows and flooring, water and sanitation facilities) and assets (e.g., ownership of home, car, computer, mobile phone) were weighted and combined with weights derived from a principal component analysis procedure.[36] The resulting variable was standardized to a

mean of 0 and standard deviation of 1 and using this index the household population was divided into fifths from poorest to richest. Education was categorized in four levels as no education, primary, secondary, or higher education.

Control variables Background characteristics included age, gender, religion, marital status, place of residence, and BMI. Age was defined in 10 year categories and centred about its mean (32 years) in regression models. Gender was based on self-report. Religion was categorized as Hindu, Muslim, Sikh, Buddhist, or other religion. Marital status was defined as single, married, widowed, or separated. Place of residence (rural or urban) was defined according to the 2001 Census. BMI (in kg/m²; weight in kilograms divided by the square of height in meters) was calculated for all survey respondents with valid measurements for weight and height. BMI was classified according to the following categories based on risk of type 2 diabetes and cardiovascular disease in Asian populations; less than 18.5 kg/m² (underweight); 18.5-22.93 kg/m² (acceptable risk); 23-27.45 kg/m² (increased risk); and 27.5 kg/m² or greater (high risk).[43]

Analysis

To account for the complex survey design, we employed multilevel logistic regression to model the probability of diabetes.[44] A three-level model was specified with a binary response (y , diabetes or not) for individual i in local area (village or census block primary sampling units) j in state k . The outcome diabetes, $\Pr(y_{ijk} = 1)$, was assumed to be binomially distributed $y_{ijk} \sim \text{Binomial}(1, \pi_{ijk})$ with probability π_{ijk} related to the set of independent variables X and a random effect for each level by a logit link function:

$$\text{Logit}(\pi_{ijk}) = \beta_0 + \beta X_{ijk} + v_{0k} + u_{0jk} \quad (\text{Equation 1})$$

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The right hand side of the equation consists of the fixed part linear predictor ($\beta_0 + \beta X_{ijk}$) and random intercepts attributable to ~~local areas~~ (u_{0jk}) ~~and~~ states (v_{0k}) and local areas (u_{0jk}). The intercept, β_0 represents the log odds of diabetes in the reference group, and the β -coefficients represent the differential in the log odds of diabetes compared to the reference group defined for each independent variable. Coefficients were exponentiated and presented as odds ratios for interpretation. The random intercepts are assumed to be independently and identically distributed and have variances estimated for ~~local areas~~ (σ_u^2) ~~and~~ states (σ_v^2) and local areas (σ_u^2).^[45] The variance parameters quantify heterogeneity in the log odds of diabetes at each level, after taking into account individual characteristics and place of residence in the fixed part. We expressed the variances at each level as a percentage of their contribution to the total variance from an initial model adjusting for age and gender only and from a final model accounting for all covariates.

We specified a sequence of six models during analyses. In the first three models, one SES marker (social caste, household wealth, education) was added to a model which adjusted for background characteristics (age, gender, religion, and place of residence). In the fourth mutually adjusted model, all SES markers were included along with background characteristics from the previous models. In the fifth model, BMI was included with markers of SES and background characteristics from model 4. In the sixth model, we also tested whether the association between household wealth varied across states in terms of strength or direction, given that different states vary tremendously by levels of economic development and could be considered at different levels of epidemiological transition. In

order to test this between state variability we expanded Equation 1 to allow the slope of household wealth to vary across states:

$$\text{Logit}(\pi_{ijk}) = \beta_0 + \beta_{1k} \text{wealth}_{ijk} + \beta X_{ijk} + v_{0k} + v_{1k} + u_{0jk} \quad \text{(Equation 2)}$$

The key feature of Equation 2 is that the effect of wealth on self-reported diabetes in state

k consists of the overall average effect across all states (β_1), plus a state-specific (v_{1k})

differential in this effect. We summarized and presented the results of this model as the

odds ratio for self-reported diabetes overall in India and for each state given a 1-quintile

increase in household wealth and conditional on all covariates from model 5. Additional

analyses were carried out separately for male and female samples using an identical

sequence of models (with the exclusion of gender as a background characteristic).

Estimation of Models models was done were estimated via using Markov Chain Monte

Carlo (MCMC) simulation using and the statistical software *MLwiN*. [46-47]

RESULTS

Characteristics of survey respondents by their self-reported diabetes status are given in **Table 21**. The overall prevalence of diabetes in this sample was 1.5% and this was higher in urban areas and among men (diabetes prevalence 2.0 % in urban v 1.0% in rural; 1.8% in men v 1.3% in women). Diabetes prevalence increased with age (7.5% in 50-54y v 0.3% in 18-29y), education (1.9% in higher v 1.0% in no education), household wealth (2.5% in richest v 0.4% in poorest), and BMI (4.8% in 27.5+ kg/m² v 0.6% in <18.5 kg/m²). At the state level, the prevalence of diabetes varied between 0.3% in Rajasthan and 3.3% in Kerala and was generally higher in Southern and Eastern states (Figure 21).

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In separate models that adjusted for age, marital status, religion, and place of residence, statistically significant associations were observed between SES and self-reported diabetes for each of the primary indicators-markers of SES in this study: social caste, education, and household wealth, and education. Compared to the other caste group, scheduled castes, scheduled tribes, and other backward classes had reduced odds of having diabetes with odds ratios of 0.81 (95% CI: 0.71–0.94), 0.57 (95% CI: 0.46–0.70), and 0.84 (95% CI: 0.75–0.94), respectively (**Table 32, Models 1-3**). Education showed a graded relation with diabetes and an odds ratio of 1.87 (95% CI: 1.61–2.18) for those with higher education versus those with no education. Household wealth showed a graded association with diabetes with individuals from the richest households having an odds ratio for diabetes of 4.04 (95% CI: 3.08–5.30) compared to those from the poorest households.

The effects of social caste and education were attenuated in the mutually adjusted model (model 4), suggesting that their independent effects on self-reported diabetes were at least partially mediated by the inclusion of household in this model. T—The reduced odds for diabetes remained consistent for scheduled tribes versus other caste groups (OR 0.72, 95% CI: 0.58–0.90) as did an increased odds for those with secondary education versus no education (OR 1.18, 95% CI: 1.04–1.35), however the graded relation with education was less consistent. In separate mutually adjusted models that were stratified by gender, education showed a graded association in men although it was not statistically significant with the odds ratio for diabetes men found to be 1.27 (95% CI: 0.98-1.70) for men with higher versus no education (Supplemental Table 1). Among women, those with secondary education continued to show an increased odds of self-reported diabetes

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compared to those with no education (OR 1.28, 95% CI: 1.08-1.50). Overall, ~~the~~
strong and graded relation between household wealth and diabetes remained consistent in
this model~~model 4~~ with an odds ratio for diabetes of 3.65 (95% CI: 2.83, 4.78) for the
richest versus the poorest groups; similar associations were found in the gender-specific
models (Supplemental Table 1). Type-2 diabetes is strongly influenced by body
weight.[48-50] Therefore, BMI was added to ~~the final model~~ model 5 to control for
potential confounding of the SES-diabetes relationship in this sample. In addition, BMI
was added separately in this model because its inclusion resulted in the reduction of
sample size by ~5% due to missing values for BMI. The odds ratios for caste and
education remained consistent between the mutually adjusted model and final model
which included BMI. The odds ratios for household wealth were further attenuated in the
final model, however the positive graded association remained statistically significant
with an adjusted odds ratio for those in the richest compared to the poorest households of
2.58 (95% CI: 1.99, ~~3.40~~).

Our analyses revealed dramatic variation in the prevalence of diabetes between
states and local areas in India (**Table 43**). In an initial multilevel model adjusted for age
and gender, states and local areas (defined as villages in rural areas and census blocks in
urban areas) contributed 5.9% and 10.8%, respectively, to the total variation in diabetes.
The addition of socioeconomic and demographic characteristics along with BMI to the
model reduced the variance in diabetes attributed to local areas by 41% to 6.4% but the
variation attributed to states was relatively unchanged at 5.4%.

Overall in India, the log odds for diabetes for the reference category (a 32 year old
married women, with no education, BMI <18.5 kg/m², belonging to the other caste group,

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8 in the poorest fifth of households, and living in a rural area) was -6.13 or a 0.22%
9 probability of diabetes. Compared to this national reference point, being a resident of
10 several Southern and Northeastern states was associated with a statistically significant
11 increase in the odds of diabetes (**Figure 34**). The odds ratios for self-reported diabetes
12 these states were: 2.29 (Tripura), 1.69 (Tamil Nadu), 1.69 (Kerala), 1.71 (Goa), 1.49
13 (Andhra Pradesh), and 1.56 (West Bengal). In contrast being resident of the states of
14 Rajasthan, Jammu & Kashmir, Uttar Pradesh, Punjab, Madhya Pradesh, and Assam in
15 Northern and Central India was associated with a statistically significant decrease (OR <
16 1.0) in the odds of reporting diabetes~~self-reported diabetes~~.

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26 In order to assess the variability in the SES-diabetes association across states in
27 India, a final model (model 6) was specified to allow the odds ratio for diabetes for a one-
28 quintile increase in household wealth to vary across states. In this model, the overall
29 odds ratio for diabetes in India for a one-quintile increase in household wealth was 1.31
30 (95% CI: 1.20-1.42) (Figure 4). In 15 states, the association was stronger than the
31 national average; varying between an odds ratio of 1.33 in Rajasthan and 1.55 in Jammu
32 & Kashmir. Although the association was less than the national average in 14 states, it
33 was found to be positive in 28/29 (97%) states and statistically significant in 20/29
34 (69%). Only in West Bengal was an inverse association observed, but it was not
35 statistically significant (OR 0.95 95% CI: 0.83-1.09). Odds ratios and 95% CI for the
36 overall association and across all states are presented in Supplemental Table 2. In
37 summary, the association between household wealth and self-reported diabetes was
38 consistent across the states both in direction and magnitude.
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We conducted several sensitivity analyses to assess the consistency of our findings. First, we examined whether the observed associations were related to respondents' awareness and knowledge about diabetes. To do so, we considered responses to the question, "Do you have diabetes?" as a categorical variable, comparing "yes" (diabetic)-and "don't know" (unknown) versus "no" (non-diabetic) across the same set of independent variables using a multinomial logistic model. Associations between SES variables and positive reports of diabetes from this model, which included the possibility that respondents were unaware of their diabetes status, were nearly identical to findings from the logistic model which excluded those with unknown diabetes status (**Supplemental Table 34**). The multinomial model also revealed that the richer and more highly educated respondents were less likely to report unknown "do not know" as their diabetes-status (compared to non-diabetic "no"). In addition, we examined BMI across the three categories of diabetes status (**Figure 53**). This revealed that those reporting "do not know" with unknown diabetes had the lowest BMI (mean 20.9, SD 3.7) which was largely consistent with the non-diabetic "no" group (mean 21.1, SD 3.9) and substantially lower than those reporting "yes" to diabetes those with self-reported diabetes (mean 24.4, SD 4.9). Finally, we examined interactions between socioeconomic variables (caste, education, wealth) and diabetes by residential location. Tests of these interactions were not statistically significant (P=0.20 for caste; P=0.72 for education; P=0.66 for wealth).

DISCUSSION

In this study, we have three key findings. First, measures of SES were positively associated with self-reported diabetes in the NFHS-3. Although the observed effects of

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caste and education were largely attenuated in fully adjusted models, the effect of household wealth remained positive, graded and statistically significant even after controlling for BMI. Second, we observed a large variation in the prevalence of diabetes between local areas and States in India. A few Southern and northeastern states were associated with a higher risk for reporting diabetes while several northern and central states were at lower risk after adjusting for individual characteristics and place of residence. Lastly, the observed association between household wealth and self-reported diabetes was consistent, positive, and statistically significant across a majority of states in India.

There are a few limitations to our study. First, the outcome was defined on the basis of self-reported diabetes, although interviews were conducted in person using a standardized instrument. Previous research has shown good agreement for self-reported diabetes when compared to medical records in a US population,^[51] and that that self-reported health conditions demonstrate the expected relationship with SES in India.^[52] In addition, our sensitivity analyses considering respondents who reported “~~did not know~~unknown” for ~~their~~ diabetes status were nearly identical to the main analyses. We did find, however, evidence that higher SES groups were less likely to report “did not know” as compared to “no”, which has been suggested previously on studies using self-reports of diabetes status in India.^[6] However, the “~~did not know~~unknown” group was more similar in terms of BMI, education, and wealth to the “~~non~~non-diabetic” rather than diabetic“yes” group. In addition, our findings of positive SES-diabetes associations were consistent with several studies identified in our literature review which used blood glucose measurements for the assessment of diabetes status (summarized in Table 1).

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8 Lastly, although our sample was relatively young (<55 y for men and <50 y for women)
9 it is representative of the young population of profile of India; 84% of the Indian adult
10 population (18-69 y) and 47% of the total Indian population at all ages fall within the
11 ages covered by this study.[53]. Our study does exclude approximately 12% of the Indian
12 population (women over the age of 50 and men over the age of 55) due to the sample
13 design of the NFHS.—The prevalence of diabetes increases with age and whether a
14 similar SES-diabetes relationship exists among middle and older age groups in all parts
15 India is not clear, although our findings are consistent with previous studies which have
16 included older ages.

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26 Our findings of positive SES-diabetes associations are consistent with previous
27 studies done in different parts of India. For example, an analysis of rural participants
28 from the Indian Migration Study, which sampled primarily from four large states in the
29 north, centre, and south of India [17], identified a positive SES-diabetes gradient among
30 men (8.0% prevalence in high SES group v 1.8% in low SES group), and a weaker
31 positive SES-diabetes association that was not statistically significant among women
32 (5.1% v 3.9%). In addition, a study done in an urban setting in Madras (Chennai) found
33 an odds ratio for diabetes of 2.2 (95% credible-confidence interval [CI]: 1.7-2.7) for high
34 v low SES groups.[11] One larger study conducted in urban and rural surveillance
35 locations in Northern, Southern, Eastern, and Western/Central India identified an odds
36 ratio of 3.0 (95% CI: 2.5-3.7) for self-reported diabetes for those with graduate level
37 education versus those without formal schooling.[6] Importantly, these studies were
38 limited to selected geographical areas or cities in India. Our study has added to this
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8 literature using a national population health survey with good coverage in rural areas
9 across India.

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12 Previous research in India has identified a strong positive relation between SES
13 and BMI among women and men in India. [54-56] These studies are important because
14 they have used similar markers of SES in the Indian context along with an objectively
15 defined outcome (height and weight were measured in NFHS and not self-reported).
16 BMI (along with other measures of body weight) is an important risk factor for the
17 development of type 2 diabetes. [48 50 57] Therefore, the consistency of our findings of a
18 positive SES-diabetes association after controlling for BMI is encouraging. If BMI is
19 part of the causal pathway between SES and diabetes, attenuation in the effect size for
20 markers of SES would be expected. The graded and positive relation between household
21 wealth and diabetes after accounting for BMI suggests that there are additional effects of
22 household wealth on diabetes that are not mediated by BMI. The effects of social caste
23 and education were largely attenuated after the inclusion of household wealth and prior to
24 the inclusion of BMI. Household wealth was the strongest socioeconomic factor
25 associated with self-reported diabetes, suggesting that social and behavioural changes
26 associated with diabetes in India may be more closely related to increasing wealth and/or
27 standard of living than educational attainment.

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43 When compared to other studies in India, the overall prevalence of diabetes in the
44 NFHS-3 was not high. This may have resulted from a combination of using self-reports
45 of diabetes, the younger age of the NFHS-3 target population, and sampling from the
46 general population which included a high proportion of respondents in rural areas.
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50 Among individuals over 30 years of age, the prevalence was 2.5% (3.0 % in men and
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8 2.2% in women). Other studies using in rural India using similar age groups and blood
9 measurements have reported diabetes prevalence of 4% and a study from rural Andhra
10 Pradesh found a prevalence of 12% based on combination self-report and blood
11 measurements.[17 58]
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16 The current national estimate for diabetes prevalence in India is about 7% of the
17 adult population aged 20-79. This estimate is based on 3 relatively recent and larger
18 scale studies using a combination of oral glucose tolerance testing and self-reports of
19 diabetes.[4-6] There continues to be considerable uncertainty in estimates of diabetes for
20 the whole of India due to the limited study locations (with a focus on urban areas), wide
21 variation in survey sampling methodology, differences in diabetes diagnostic criteria, and
22 age groups studied. These differences in study design have hindered direct comparison
23 of the prevalence between studies, across regions and over time. The NFHS-3 provides
24 and important benchmark because it is the first nationally-representative survey of
25 diabetes in India. Even if the prevalence estimates of diabetes have been underestimated
26 in the NFHS-3, the observed SES-diabetes associations are plausible and important.
27 Previous studies have largely overlooked the importance of socioeconomic status
28 markers, which may be a key determinant of diabetes. Further large-scale population-
29 based surveys can be strengthened by using simple finger-prick blood glucose
30 measurements in addition to self-reports.
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45 There has been considerable concern over the rising prevalence of diabetes in
46 India, especially with studies on migrant Indian populations suggesting that South Asians
47 may be more susceptible to the disease. In light of current findings, it appears that, at
48 present, the more well-off segments of the Indian population are at greatest risk. This
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9 poses concerns on how to appropriately balance priorities to address the disease burden
10 that afflicts the non poor versus the poor in the context of India where greater than 40%
11 of the population continue to live in extreme poverty ~~-50 percent on~~ less than \$1.25 per
12 day~~[48] of the population are poor~~.^[59]
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18 ACKNOWLEDGEMENTS

19 SVS and DJC planned the study. DJC conducted statistical analyses and drafted the
20 manuscript with supervision from SVS. Both authors participated in interpretation of the
21 results and critical revisions of the manuscript.
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25 The NFHS data are available through the Measure DHS project at www.measuredhs.com.
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Table 1: Overview of studies reporting prevalence of type-2 diabetes by markers of socioeconomic status (SES) and the association between increasing SES and diabetes in India

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Author	Study period	Coverage	Setting	Age	Sample size	Diabetes assessment	SES marker	Gender	Diabetes prevalence: low SES (l); high SES (h)	SES-diabetes association: Odds ratio (95% confidence interval), high SES vs low SES
Singh[7]	1994	Local	Rural	25-64	1769	blood glucose	Composite	Male	0.9% (l); 6.1% (h)*	-
								Female	0.9% (l); 6.9% (h)*	-
Singh[8]	1994	Local	Rural	25-64	1806	blood glucose	Composite	Male	2.5% (l); 8.6% (h)*	2.03 (1.86-2.51)*
								Female	1.2% (l); 6.9% (h)*	1.97 (1.67-2.36)*
Singh[9]	1994	Local	Combined	25-64	3575	blood glucose	Composite	Male	-	4.07 (1.89-10.01)* (Urban)
								-	3.75 (1.37-12.78)* (Rural)	
								Female	-	1.48 (0.64-4.00) (Urban)
								-	2.55 (0.91-8.83) (Rural)	
Singh[10]	1998	Regional	Urban	25-64	3257	blood glucose	Composite	Female	0.5% (l); 4.8% (h)*	-
Ramachandran[4]	2000	Regional	Urban	20+	11216	blood glucose	Income	Combined	12.5% (l); 21.6% (h)*	1.43 (1.30-1.57)*; 1.16 (1.05-1.30)*
Ramachandran[11]	1999-2000	Local	Urban	40+	2383	blood glucose, drug treatment	Income	Combined	12.6% (l); 25.5% (h)*	2.15 (1.70-2.72)
Gupta[12]	1999-2001	Local	Urban	20+	1123	self-report	Education	Male	6.8% (l); 7.9% (h)	-
								Female	6.6% (l); 8.3% (h)	-

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Reddy[13]	2002-2003	Regional	Urban	20-69	19973	blood glucose, drug treatment	Education	Male	7.6% (l); 8.4% (h)	1.11 (0.71-1.67)
								Female	11.2% (l); 4.2% (h)*	0.36 (0.23-0.56)*
Mohan[6]	2003-2005	Regional	Combined	15-64	44523	self-report	Education	Combined	3.4% (l); 5.6% (h)*	3.02 (2.45-3.71)*
Ajay[14]	2002-2003	Regional	Urban	20-69	10930	blood glucose, drug treatment	Education	Combined	11.6% (l); 6.9% (h)*	0.69 (0.54-0.89)*
Vijayakumar[15]	2007	Local	Rural	18+	1990	blood glucose, self-report	Social caste	Combined	5.9% (l); 17.4% (h)	-
							Wealth	Combined	1.43 (1.04-1.95)*	
Gupta[16]	1999-2003	Local	Urban	20-59	1289	blood glucose, self-report	Education	Male	8.0% (l); 18.8% (h)*	-
								Female	6.0% (l); 34.7% (h)*	-
								Combined	6.9% (l); 26.4% (h)*	-
Kinra[17]	2005-2007	Regional	Rural	20-69	1983	blood glucose, self-report	Wealth	Male	1.8% (l); 8.0% (h)*	-
								Female	3.9% (l); 5.1% (h)	-
Samuel[18]	1969-2002	Regional	Urban	26-32	2218	blood glucose [†] , drug treatment	Wealth	Male	26.2% (l); 31.9% (h)* (Urban)	-
									10.9% (l); 31.8% (h) (Rural)	-
			Rural		Female	12.1% (l); 30.3% (h)* (Urban)	-			
						16.1% (l); 32.1% (h)* (Rural)	-			
			Combined		Combined	-	2.8 (1.9-4.1)*			
			Urban		Education	Male	15.0% (l); 34.7% (h) (Urban)	-		

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Zaman[19]	2005	Regional	Rural	30+	4535	blood glucose, self-report	Income		25.7% (l); 19.7% (h)	-	
								Rural	Female	31.5% (l); 32.2% (h)*	-
									(Urban)		
										19.1% (l); 50.0% (h)	-
								Combined	Combined	-	1.0 (0.6-1.6)
									Male	16.2% (l); 21.2% (h)*	-
									Female	12.1% (l); 15.0% (h)*	-
								Education	Male	12.4% (l); 20.1% (h)*	-
	Female	12.8% (l); 13.1% (h)	-								

Notes for Table 1: Socioeconomic status (SES) markers defined as education, household wealth, social caste, or a composite of 2 or more measures; *P<0.05; - indicates not reported; †includes impaired glucose tolerance and impaired fasting glucose

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Table 12: Characteristics of survey participants and frequency distribution of self-reported diabetes in India, males and females from the 3rd National Family Health Survey

	<u>Self-reported</u> <u>Diabetes</u>		<u>Total</u>
	<i>n</i>	%	<i>n</i>
Participants	2439	1.5	168135
Residence			
Rural	818	1.0	86013
Urban	1621	2.0	82122
Age group			
18-29 y	266	0.3	76174
30-39 y	602	1.2	51132
40-49 y	1238	3.4	36402
50-54 y	333	7.5	4427
Gender			
Male	1144	1.8	65255
Female	1295	1.3	102880
Marital status			
Single	132	0.3	38078
Married	2165	1.8	123457
Widowed	108	2.5	4320
Divorced or separated	34	1.5	2280
Religion			
Hindu	1775	1.4	123411
Muslim	340	1.6	21510
Christian	213	1.4	14779
Sikh	49	1.5	3236
Buddhist	34	1.4	2451
Other	28	1.0	2748
Social Caste			
Other caste	1026	1.8	56063
Scheduled caste	349	1.3	27677
Scheduled tribe	167	0.8	21372
Other backward class	781	1.4	55641
No caste	116	1.6	7382
Education			
No education	464	1.0	44856
Primary	358	1.4	24969

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Secondary	1166	1.6	74715
Higher	451	1.9	23595
Household wealth			
Poorest	77	0.4	17252
2 nd quintile	175	0.8	22948
3 rd quintile	278	0.9	32070
4 th quintile	573	1.4	42091
Richest	1336	2.5	53774
Body mass index (kg/m ²)			
<18.5	243	0.6	42128
18.5-22.9	703	0.9	74089
23-27.4	833	2.7	31217
27.5+	547	4.8	11502

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Table 32: Associations between socioeconomic status and self-reported diabetes in India; 3rd National family health survey, 2005-6

Variable	Model-adjusted for age, gender, marital status, religion, residence Models 1-3		Mutually adjusted model Model 4		Mutually adjusted model with BMI Model 5	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Social Caste						
Other caste	1.00		1.00		1.00	
Scheduled caste	0.81	(0.71 - 0.94)	1.05	(0.91 - 1.21)	1.07	(0.93 - 1.24)
Scheduled tribe	0.57	(0.46 - 0.70)	0.72	(0.58 - 0.90)	0.73	(0.57 - 0.92)
Other backward caste	0.84	(0.75 - 0.94)	0.95	(0.85 - 1.07)	0.96	(0.86 - 1.08)
No caste	0.89	(0.71 - 1.11)	0.94	(0.75 - 1.17)	0.95	(0.76 - 1.20)
Wealth						
Poorest	1.00		1.00		1.00	
2nd quintile	1.59	(1.20 - 2.12)	1.57	(1.21 - 2.07)	1.49	(1.14 - 1.96)
3rd quintile	1.63	(1.23 - 2.16)	1.55	(1.21 - 2.02)	1.39	(1.07 - 1.81)
4th quintile	2.42	(1.85 - 3.17)	2.25	(1.76 - 2.92)	1.79	(1.40 - 2.34)
Richest	4.04	(3.08 - 5.30)	3.65	(2.83 - 4.78)	2.58	(1.99 - 3.40)
Education						
No education	1.00		1.00		1.00	
Primary	1.23	(1.06 - 1.43)	1.06	(0.91 - 1.22)	1.00	(0.86 - 1.17)
Secondary	1.68	(1.49 - 1.90)	1.18	(1.04 - 1.35)	1.12	(0.98 - 1.28)
Higher	1.87	(1.61 - 2.18)	1.12	(0.95 - 1.32)	1.01	(0.86 - 1.20)
Body mass index (kg/m ²)						
<18.5					1.00	
18.5-22.9	2.93				1.25	(1.08 - 1.46)
23-27.4	1.45				2.08	(1.79 - 2.44)
27.5+					2.98	(2.51 - 3.54)

Notes: In models 1-3 one SES marker (social caste, household wealth, education) was modelled at a time while adjusting for age, gender, religion, and place of residence. In model 4, all SES markers were included along with covariates from models 1-3. In model 5, BMI was included with markers of SES and covariates from model 4.

Table 34: Variance in self-reported diabetes status between local areas and states in India; expressed as percentage of the contribution to the total variance in diabetes

	Age & gender adjusted*			Fully adjusted**		
	Variance	SE	%	Variance	SE	%
States	0.231	0.076	5.9	0.204	0.068	5.4
Local areas	0.425	0.043	10.8	0.240	0.041	6.4

Notes:

*Multilevel model adjusted for age and gender only

**Multilevel model fully adjusted for age, gender, marital status, religion, social caste, household wealth, education, body mass index, and place of residence

State	#	Self-reported diabetes	
		Wealth OR	95% CI*
India	158,936	1.31	(1.20– 1.42)
Jammu and Kashmir	3,383	1.55	(1.21– 1.98)
Maharashtra	14,053	1.51	(1.27– 1.78)
Orissa	4,838	1.50	(1.24– 1.81)
Arunachal Pradesh	1,798	1.49	(1.14– 1.94)
Uttar Pradesh	17,555	1.47	(1.28– 1.70)
Sikkim	2,406	1.46	(1.11– 1.92)
Madhya Pradesh	7,756	1.43	(1.19– 1.71)
Assam	3,904	1.43	(1.15– 1.77)
Uttaranchal	3,120	1.42	(1.12– 1.81)
Punjab	4,134	1.41	(1.10– 1.81)
Mizoram	2,089	1.40	(1.07– 1.85)
Karnataka	9,049	1.40	(1.19– 1.64)
Chhattisgarh	4,246	1.36	(1.14– 1.64)
Delhi	3,026	1.35	(1.05– 1.73)
Rajasthan	4,433	1.33	(1.03– 1.71)
Meghalaya	2,135	1.29	(1.03– 1.63)
Jharkhand	3,044	1.29	(1.06– 1.57)
Tamil Nadu	10,106	1.28	(1.11– 1.48)
Andhra Pradesh	11,824	1.25	(1.09– 1.45)
Himachal Pradesh	3,563	1.25	(0.97– 1.61)
Gujarat	4,322	1.25	(1.00– 1.56)
Goa	3,883	1.20	(0.98– 1.48)
Nagaland	6,350	1.19	(0.99– 1.44)

Tripura	2,089	1.18	(0.96– 1.45)
Manipur	6,941	1.14	(0.95– 1.37)
Haryana	3,173	1.11	(0.90– 1.38)
Bihar	3,882	1.10	(0.93– 1.30)
Kerala	4,018	1.10	(0.89– 1.35)
West Bengal	7,816	0.95	(0.83– 1.09)

Notes: Odds ratios (OR) and 95% credible intervals (CI) adjusted for age, gender, marital status, religion, social caste, education, body mass index and place of residence.

FIGURE LEGENDS

Figure 1 Flow diagram showing exclusions and final sample sizes, 2005-6 National Family Health Survey (NFHS)

Notes for figure 1: *2,333 individuals reported unknown diabetes status; in 40 individuals diabetes status was not reported/missing. Of the 2,333 individuals who reported unknown diabetes status, 2,210 (94.7%) had complete data for BMI and were included in sensitivity analyses.

**Analyses involving body mass index (BMI) as an independent variable were restricted to 158,936 individuals.

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Figure 2 State level prevalence of self-reported diabetes in India for men aged 18-54 (left) and women aged 18-49 (right). Darker colours indicate higher prevalence.

Notes for figure 2: State name abbreviations: AP Andhra Pradesh; AR Arunachal Pradesh; AS Assam; BR Bihar; CT Chhattisgarh; DL Delhi; GA Goa; GJ Gujarat; HR Haryana; HP Himachal Pradesh; JK Jammu & Kashmir; JH Jharkhand; KA Karnataka; KL Kerala; MP Madhya Pradesh; MH Maharashtra; MN Manipur; ML Meghalaya; MZ Mizoram; NL Nagaland; OR Orissa; PB Punjab; RJ Rajasthan; SK Sikkim; TN Tamil Nadu; TR Tripura; UP Uttar Pradesh; UK Uttarakhand (Uttaranchal); WB West Bengal

Figure 3 Odds ratios for self-reported diabetes by state of residence in India

Notes for figure 3: horizontal lines are 95% credible intervals; Notes for adjusted for age, gender, marital status, religion, social caste, household wealth, education, body mass index and place of residence.

Figure 4 Odds ratio (OR) for self-reported diabetes for a one-quintile increase in household wealth for men (aged 18-54) and women (aged 18-49) in India and 29 states

Notes for figure 4: Adjusted for age, gender, marital status, religion, social caste, education, body mass index and place of residence.

Figure 5 Mean body mass index across three possible responses for self-reported diabetes (Not known—diabetes status not known, No—do not have diabetes, Yes—have diabetes).

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Notes for figure 5: Vertical lines represent 95% confidence intervals. Body mass index (in kg/m²) ~~objectively defined based on~~ calculated from measured height and weight values. Horizontal line represents overall mean body mass index (21.2 kg/m², SD 3.9).

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SUPPLEMENTAL MATERIAL

Supplemental Table 1 Associations between socioeconomic status and self-reported diabetes in India from models restricted to male and female samples; 3rd National family health survey 2005-6

Variable	Men aged 18-54						Women aged 18-49											
	Models 1-3			Model 4			Model 5			Models 1-3			Model 4			Model 5		
	O	R	95% CI	O	R	95% CI	O	R	95% CI	O	R	95% CI	O	R	95% CI	O	R	95% CI
Social Caste	1.0			1.0			1.0			1.0			1.0			1.0		
Other caste	0			0			0			0			0			0		
Scheduled caste	0.8	(0.68	1.0	1.1	(0.92	1.3	1.2	(0.96	1.4	0.7	(0.64	0.9	0.9	(0.78	1.1	0.9	(0.79	1.1
Scheduled tribe	4	-	3)	4	-	9)	0	-	8)	7	-	3)	5	-	4)	7	-	6)
Other backward caste	0.5	(0.40	0.7	0.7	(0.52	1.0	0.7	(0.56	1.0	0.5	(0.39	0.7	0.6	(0.48	0.8	0.6	(0.48	0.8
No caste	5	-	5)	3	-	0)	8	-	7)	4	-	1)	5	-	7)	4	-	7)
Wealth	0.8	(0.74	1.0	1.0	(0.86	1.1	1.0	(0.88	1.2	0.7	(0.67	0.9	0.8	(0.74	1.0	0.8	(0.75	1.0
Poorest	6	-	0)	1	-	9)	4	-	3)	8	-	1)	6	-	1)	7	-	2)
2nd quintile	0.9	(0.62	1.3	0.9	(0.65	1.4	1.0	(0.71	1.5	0.8	(0.66	1.1	0.9	(0.68	1.2	0.9	(0.67	1.2
3rd quintile	2	-	7)	6	-	0)	4	-	2)	7	-	6)	0	-	1)	1	-	2)
4th quintile	1.0			1.0			1.0			1.0			1.0			1.0		
Richest	0			0			0			0			0			0		
Education	1.4	(0.97	2.1	1.3	(0.94	1.9	1.3	(0.89	1.8	1.7	(1.17	2.4	1.6	(1.15	2.4	1.6	(1.18	2.5
No education	0	-	1)	5	-	7)	2	-	8)	2	-	6)	6	-	4)	9	-	2)
Primary	1.4	(1.03	2.1	1.3	(0.95	1.9	1.2	(0.88	1.8	1.7	(1.17	2.5	1.6	(1.10	2.2	1.4	(1.07	2.2
Wealth	6	-	5)	6	-	6)	9	-	0)	3	-	2)	0	-	6)	8	-	5)
2nd quintile	2.1	(1.51	3.1	1.8	(1.34	2.6	1.6	(1.14	2.2	2.6	(1.79	3.8	2.3	(1.64	3.3	1.8	(1.38	2.8
3rd quintile	0	-	0)	7	-	2)	5	-	8)	6	-	7)	4	-	2)	9	-	3)
4th quintile	4.5	(3.22	6.8	3.8	(2.73	5.3	3.0	(2.05	4.2	3.6	(2.42	5.4	3.1	(2.19	4.4	2.2	(1.62	3.3
Richest	5	-	1)	2	-	7)	4	-	7)	7	-	1)	6	-	7)	4	-	2)
Education	1.0			1.0			1.0			1.0			1.0			1.0		
No education	0			0			0			0			0			0		
Primary	1.1	(0.86	1.3	0.9	(0.75	1.2	0.9	(0.70	1.2	1.3	(1.16	1.6	1.1	(0.98	1.4	1.1	(0.92	1.3

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	0	-	8)	6	-	1)	2	-	0)	9	-	7)	7	-	0)	1	-	3)
	1.6	(1.37	2.0	1.1	(0.90	1.4	1.0	(0.85	1.3	1.7	(1.52	2.0	1.2	(1.08	1.5	1.2	(1.02	1.4
Secondary	6	-	1)	3	-	4)	7	-	6)	6	-	2)	8	-	0)	1	-	3)
	2.3	(1.87	2.9	1.2	(0.98	1.7	1.1	(0.86	1.4	1.4	(1.12	1.7	0.9	(0.72	1.1	0.8	(0.66	1.0
Higher	6	-	2)	7	-	0)	3	-	8)	0	-	3)	1	-	5)	5	-	8)
Body mass index (kg/m ²)																		
<18							1.0						1.0					
							0						0					
							1.2	(0.99	1.5				1.2	(1.01	1.5			
18.5-22.9							5	-	5)				4	-	3)			
							2.0	(1.59	2.5				2.1	(1.75	2.6			
23-27.4							0	-	0)				2	-	8)			
							2.1	(1.65	2.8				3.5	(2.89	4.5			
27.5+							5	-	6)				8	-	6)			

Notes: OR odds ratio; In models 1-3 one SES marker (social caste, household wealth, education) was modelled at a time while adjusting for age, gender, religion, and place of residence. In model 4, all SES markers were included along with covariates form models 1-3. In model 5, BMI was included with markers of SES and covariates from model 4.

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Supplemental Table 2 Odds ratio (OR) for self-reported diabetes for a one-quintile increase in household wealth for men (aged 18-54) and women (aged 18-49) in India and 29 states

State	n	Self-reported diabetes	
		Wealth OR	95% CI*
India	158,936	1.31	(1.20 - 1.42)
Jammu and Kashmir	3,383	1.55	(1.21 - 1.98)
Maharashtra	14,053	1.51	(1.27 - 1.78)
Orissa	4,838	1.50	(1.24 - 1.81)
Arunachal Pradesh	1,798	1.49	(1.14 - 1.94)
Uttar Pradesh	17,555	1.47	(1.28 - 1.70)
Sikkim	2,406	1.46	(1.11 - 1.92)
Madhya Pradesh	7,756	1.43	(1.19 - 1.71)
Assam	3,904	1.43	(1.15 - 1.77)
Uttaranchal	3,120	1.42	(1.12 - 1.81)
Punjab	4,134	1.41	(1.10 - 1.81)
Mizoram	2,089	1.40	(1.07 - 1.85)
Karnataka	9,049	1.40	(1.19 - 1.64)
Chhattisgarh	4,246	1.36	(1.14 - 1.64)
Delhi	3,026	1.35	(1.05 - 1.73)
Rajasthan	4,433	1.33	(1.03 - 1.71)
Meghalaya	2,135	1.29	(1.03 - 1.63)
Jharkhand	3,044	1.29	(1.06 - 1.57)
Tamil Nadu	10,106	1.28	(1.11 - 1.48)
Andhra Pradesh	11,824	1.25	(1.09 - 1.45)
Himachal Pradesh	3,563	1.25	(0.97 - 1.61)
Gujarat	4,322	1.25	(1.00 - 1.56)
Goa	3,883	1.20	(0.98 - 1.48)
Nagaland	6,350	1.19	(0.99 - 1.44)
Tripura	2,089	1.18	(0.96 - 1.45)
Manipur	6,941	1.14	(0.95 - 1.37)
Haryana	3,173	1.11	(0.90 - 1.38)
Bihar	3,882	1.10	(0.93 - 1.30)
Kerala	4,018	1.10	(0.89 - 1.35)
West Bengal	7,816	0.95	(0.83 - 1.09)

Notes: Odds ratios (OR) and 95% credible intervals (CI) adjusted for age, gender, marital status, religion, social caste, education, body mass index and place of residence.

Supplemental Table 13 Associations between socioeconomic status and body mass index, for self-reported diabetics and those with es, and unknown diabetes status compared to self-reported non-diabetics using a multilevel multinomial regression model.

Variable	<u>Diabetes Self-reported diabetes</u>		<u>Diabetes not known Unknown diabetes status</u>	
	Odds ratio	95% CI*	Odds ratio	95% CI
Social Caste				
Other caste	1.00		1.00	
Scheduled caste	1.07	(0.93 - 1.24)	1.13	(0.96 - 1.31)
Scheduled tribe	0.73	(0.58 - 0.91)	1.52	(1.25 - 1.84)
Other backward caste	0.96	(0.86 - 1.08)	1.07	(0.93 - 1.23)
No caste	0.95	(0.75 - 1.18)	0.76	(0.58 - 0.99)
Wealth				
Poorest	1.00		1.00	
2nd quintile	1.51	(1.14 - 2.03)	0.90	(0.77 - 1.05)
3rd quintile	1.41	(1.07 - 1.89)	0.86	(0.73 - 1.01)
4th quintile	1.82	(1.38 - 2.44)	0.82	(0.68 - 0.98)
Richest	2.63	(1.97 - 3.56)	0.64	(0.51 - 0.79)
Education				
No education	1.00		1.00	
Primary	1.00	(0.87 - 1.17)	0.86	(0.76 - 0.99)
Secondary	1.12	(0.98 - 1.28)	0.71	(0.63 - 0.81)
Higher	1.01	(0.85 - 1.21)	0.45	(0.36 - 0.57)
Body mass index				
<18.5	1.00		1.00	
18.5-22.93	1.26	(1.08 - 1.46)	1.03	(0.93 - 1.15)
23-27.45	2.09	(1.79 - 2.45)	1.17	(1.01 - 1.36)
27.5+	2.99	(2.52 - 3.55)	1.33	(1.06 - 1.66)

Notes: model adjusted for age, gender, religion, marital status, place of residence
*95% credible interval

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109,041 households (198,754 adults)
in NFHS (74,369 men; 124,385 women)

21,940 (11.0%) individuals aged <18;
5,670 (4.5%) pregnant women

171,207 (86.1%) individuals
eligible for main analyses

168,135 (98.2%) individuals
in main analyses

2,373 (1.4%) unknown
diabetes status*;
699 (0.4%) missing covariates

65,255 (38.8%) men
aged 18-54

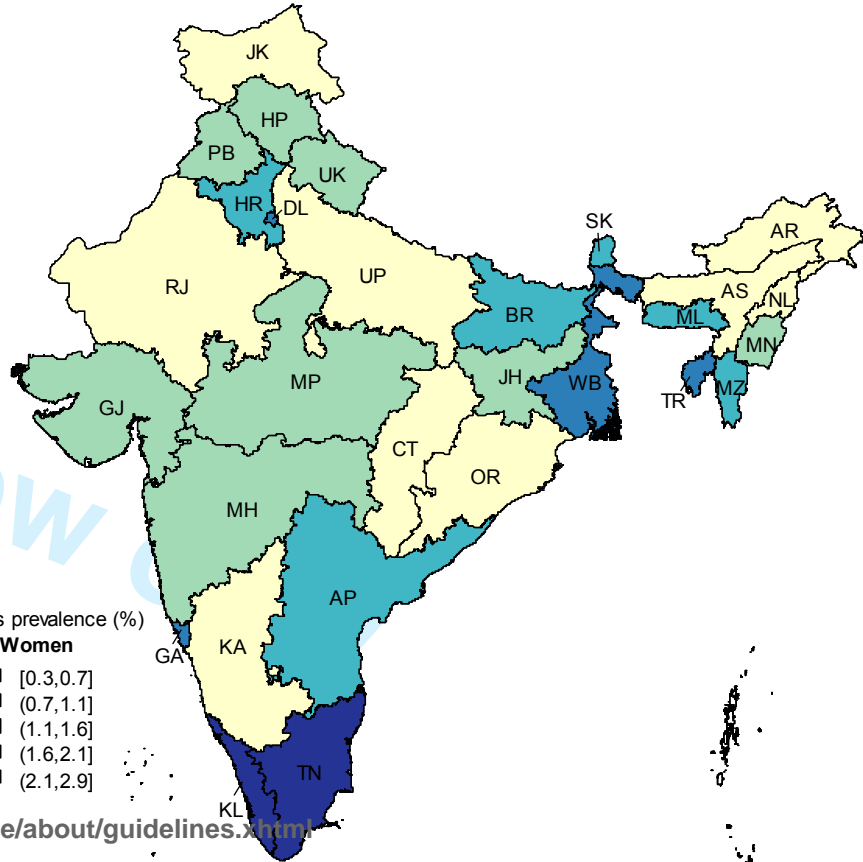
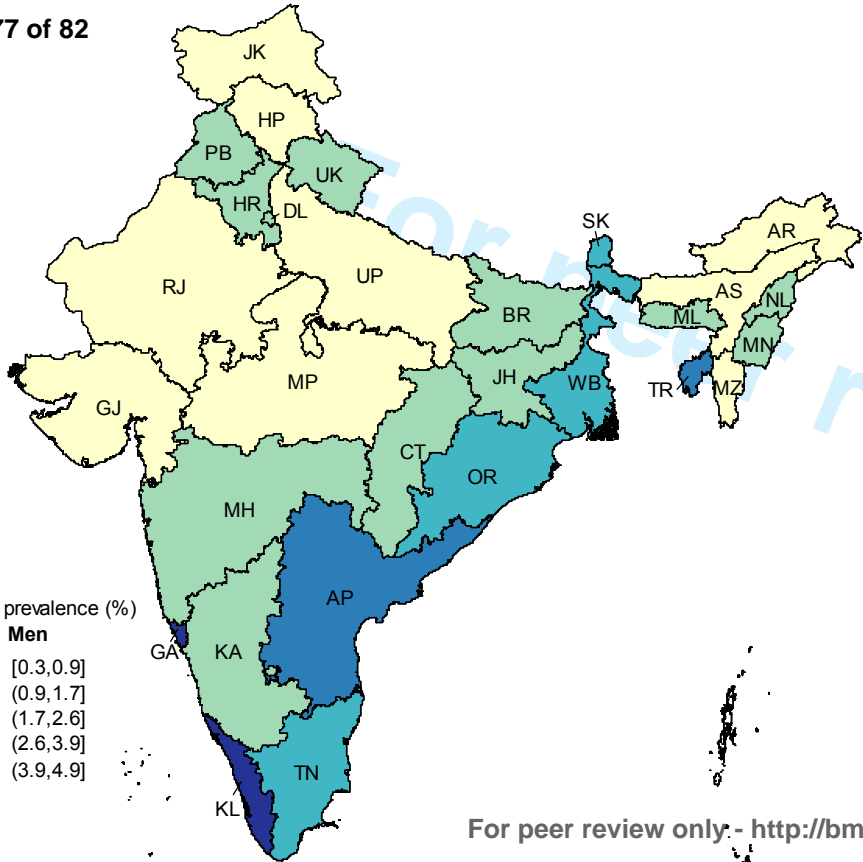
102,880 (62.2%) women
aged 18-49

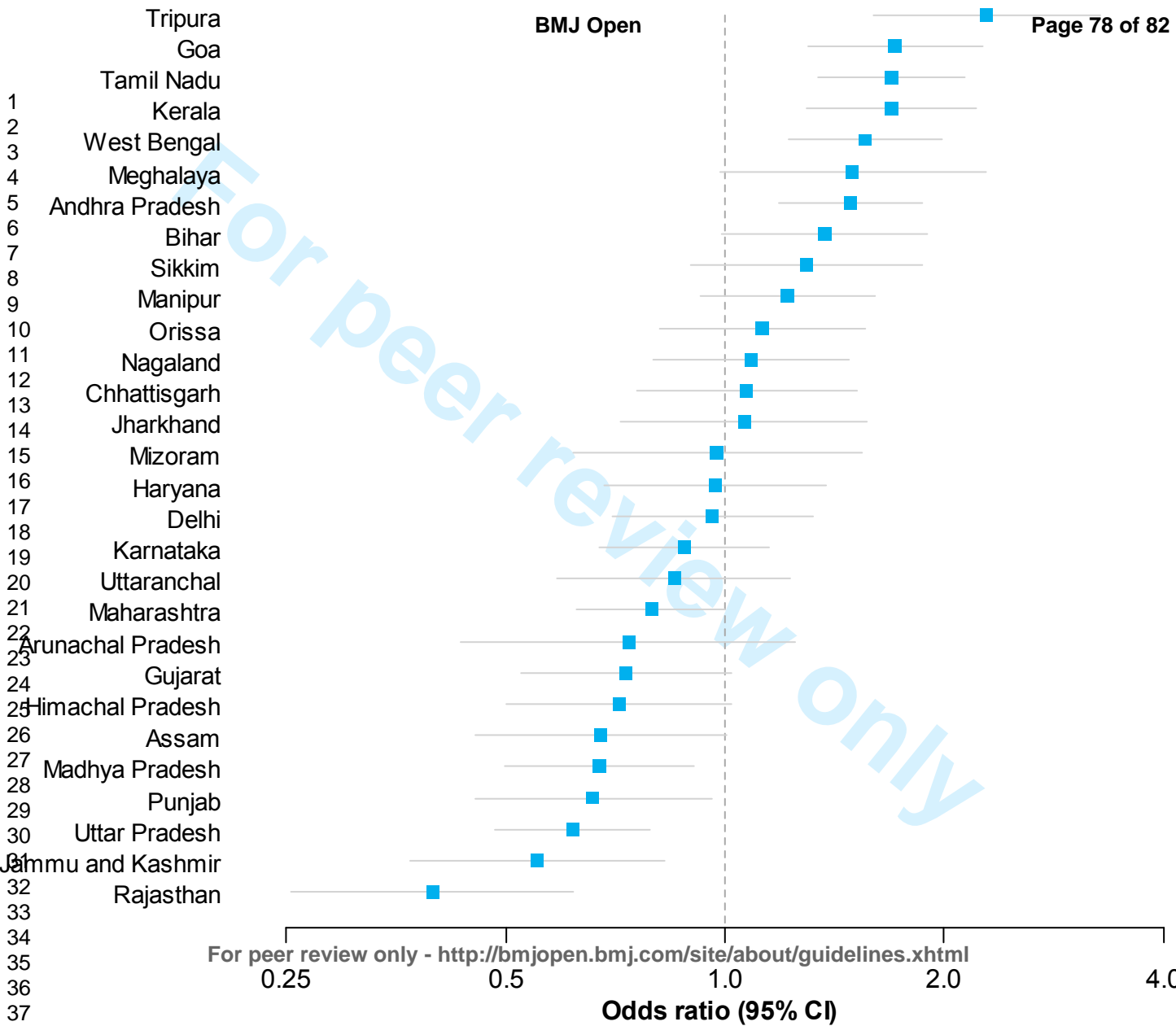
158,936 (94.5%) individuals
with data on BMI**

60,691 (38.2%)
men

98,245 (61.8%)
women

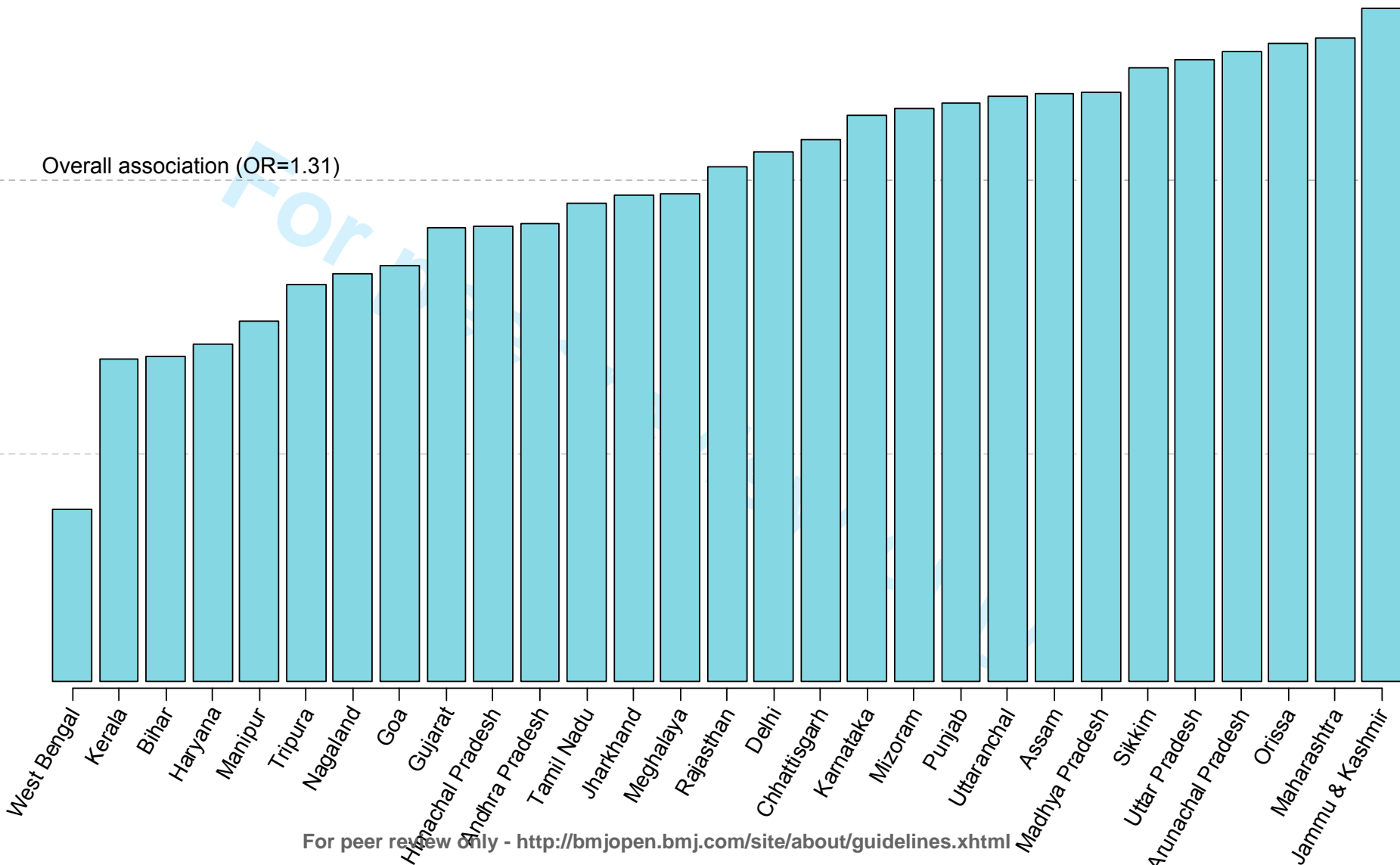
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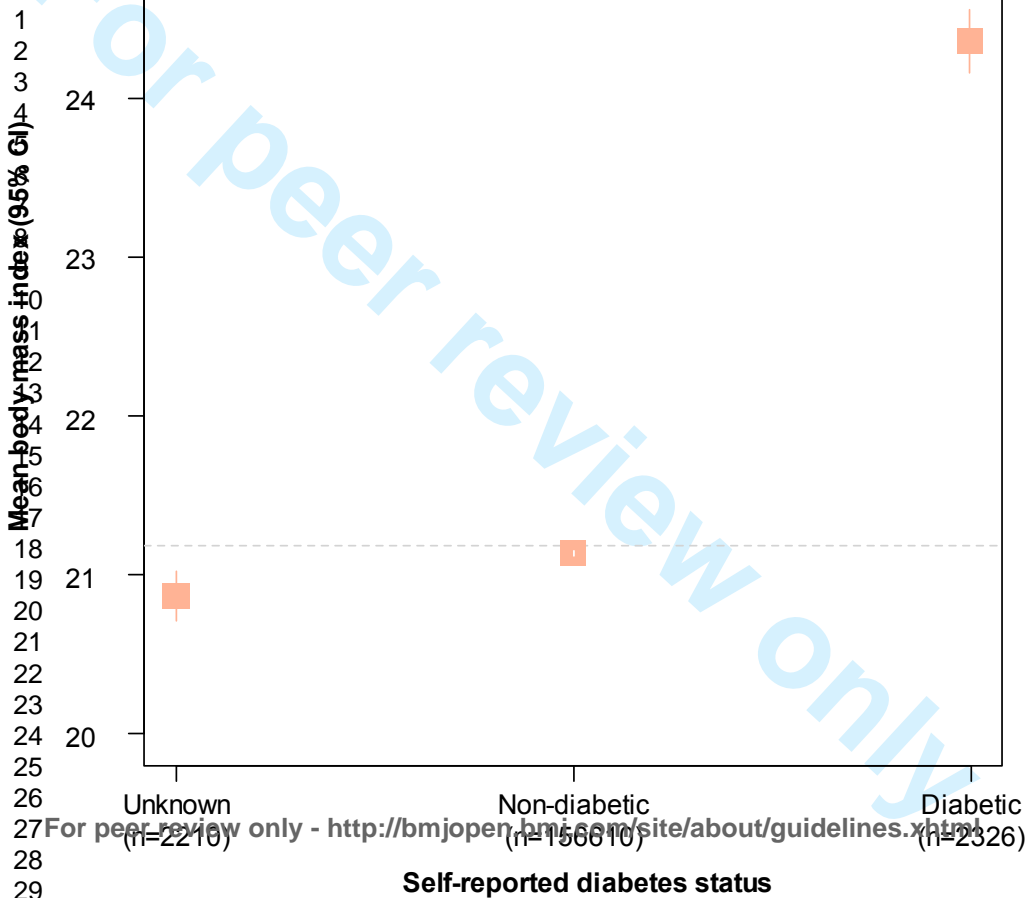




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Overall association (OR=1.31)





STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Article: Association between socioeconomic status and diabetes in India

Authors: Daniel J Corsi, SV Subramanian

	Item No	Recommendation
Title and abstract	1	(a) Design cross-sectional study, listed in abstract (b) abstract and article summary (page 3)
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported, (abstract, page 3, page 4-5)
Objectives	3	State specific objectives, including any prespecified hypotheses (abstract, page 3, page 4-5)
Methods		
Study design	4	Present key elements of study design early in the paper (abstract, page 6)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection (abstract, page 5-7)
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants (page 6)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable (page 7)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group (page 7-8)
Bias	9	Describe any efforts to address potential sources of bias (page 8-9; page 12)
Study size	10	Explain how the study size was arrived at (page 7)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why (page 8)
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (page 8-9) (b) Describe any methods used to examine subgroups and interactions (page 12) (c) Explain how missing data were addressed (page 7) (d) If applicable, describe analytical methods taking account of sampling strategy (page 8) (e) Describe any sensitivity analyses (page 12)
Results		
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (page 8) (b) Give reasons for non-participation at each stage (n/a) (c) Consider use of a flow diagram (n/a)
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (page 9-10, table 1) (b) Indicate number of participants with missing data for each variable of interest (page 7; page 12)
Outcome data	15*	Table 1
Main results	16DJC	(a) Tables 1 (unadjusted), 2 (age, gender, marital status, religion, place of residence adjusted; and fully adjusted model)

		(b) Report category boundaries when continuous variables were categorized (in methods, e.g. for BMI)
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period (n/a)
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses (Page 12)
Discussion		
Key results	18	Summarise key results with reference to study objectives (page 13)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (page 13)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (page 16)
Generalisability	21	Discuss the generalisability (external validity) of the study results (pages 14-15)
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (title page)

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.