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ORIGINAL ARTICLE

# Socioeconomic patterning of chronic conditions and behavioral risk factors in rural South Asia: a multi-site cross-sectional study

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**Abstract**
*Objectives* Our aim was to examine relationships between markers of socioeconomic status and chronic disease risks in rural South Asia to understand the etiology of chronic diseases in the region and identify high-risk populations.
*Methods* We examined data from 2271 adults in Chennai, Goa and Matlab sites of the Chronic Disease Risk Factor study in South Asia. We report age–sex adjusted odds ratios for risk factors (tobacco, alcohol, fruit–vegetable use and physical activity) and common chronic conditions (hypertension, diabetes, overweight, depression, impaired lung and vision) by education, occupation and wealth.
*Results* Respondents with greater wealth and in non-manual professions were more likely to be overweight [OR = 2.48 (95% CI 1.8,3.38)] and have diabetes [OR = 1.88 (95% CI 1.02,3.5)]. Wealth and education were associated with higher fruit and vegetable [OR = 1.89 (95% CI 1.48,2.4)] consumption but lower physical activity [OR = 0.52 (95% CI 0.39,0.69)]. Non-manual workers reported lower tobacco and alcohol use, while wealthier respondents reported better vision and lung function.
*Conclusions* Ongoing monitoring of inequalities in chronic disease risks is needed for planning and evaluating interventions to address the growing burden of chronic conditions.

**Keywords** Chronic diseases · South Asia · Socioeconomic inequalities · Behavioral risk factors · Socioeconomic status

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## Introduction

Chronic conditions (CCs) are rapidly rising in South Asia. In India and Bangladesh, CCs contribute to more than half of the annual mortality and morbidity (Patel et al. 2011; Bleich et al. 2011; Abegunde et al. 2007). In other South Asian countries, the burden of chronic conditions is also increasing (Abegunde et al. 2007; Ghaffar et al. 2004; Katulanda et al. 2008). The rise of CCs in South Asia is leading to concerns about factors associated with their spread, particularly among vulnerable populations (Beaglehole et al. 2011a; Reddy et al. 2005). For instance, some studies show disproportionate mortality and morbidity from chronic conditions in poorer households (Reddy et al. 2005; Prabhakaran et al. 2013). This is attributed to lower rates of awareness of risk factors, limited access to healthcare and high treatment costs leading to worsening of conditions (Reddy et al. 2005; Prabhakaran et al. 2013; Bhojani et al. 2012). The rise of chronic conditions in

South Asia is also associated with increasing urbanization (Leon 2008; Ebrahim et al. 2010; Allender et al. 2010) and related risk factors such as sedentary behaviors, consumption of processed foods and changing environmental risks from smoking, motor vehicle use and industrialization.

Growing research on chronic conditions in South Asia has highlighted the importance of studying chronic conditions in light of urbanization (Oyebode et al. 2015; Mohan et al. 2008; Ebrahim et al. 2010; Garg and Karan 2009). Many of these studies in South Asia have used evidence from rural–urban comparisons to show greater burdens of disease in urban environments. While this is important in light of the changing socioeconomic and health transition, this approach has led to a neglect of empirical research on chronic conditions and their risk factors in rural settings. Studies on chronic conditions in rural settings can highlight transitions and mechanisms that may have influence on chronic disease risks in two ways. First, current definitions of urban and rural are based on metrics of population density and occupation and do not account for a spectrum of other transitioning factors (e.g., economic activity, transport, communication and social norms) among rural settings likely to influence chronic conditions and risk factors (Allender et al. 2010; Oyebode et al. 2015). The transition of rural areas into peri-urban is often not captured by statistics. Second, chronic conditions include a diverse group of diseases and their risk factors with multifactorial determinants, many of which are present, albeit in diverse forms in both rural and urban areas. For instance, lung function is not only influenced by urban vehicular pollution but also indoor air pollution from cooking stoves in rural settings (Ingle et al. 2005; Smith et al. 1983; Vineis et al. 2014). Hence, investigating the prevalence, correlates and heterogeneity of chronic conditions in rural settings is needed to highlight specific risk pathways and examine similarities and differences with SES pathways in urban settings.

South Asian countries are undergoing socioeconomic and cultural transition seen through migration, changes in economic activity, urbanization, rising rates of education and women's empowerment (Yusuf and Ôunpuu 2001; Yusuf et al. 2001; Hawkes 2006). These changes have implications for the lives of rural residents and may influence risks and resilience towards chronic conditions (Yusuf and Ôunpuu 2001; Yusuf et al. 2001; Hawkes 2006; Beaglehole et al. 2011b; Travasso et al. 2014; Narayan et al. 2010; McKay et al. 2015). Some of these changes have been linked to urbanization; however, given the diverse pathways linking transition to rural settings and the degrees of urbanicity, understanding socioeconomic inequalities in chronic conditions in rural settings can help in answering key questions related to the etiology of these illnesses.

With this aim, we conducted this study to examine the association between markers of socioeconomic status and chronic conditions and behavioral risk factors across three rural sites in South Asia. Understanding the socioeconomic patterning of chronic conditions may identify key factors related to the etiology and populations at high risk of developing chronic diseases in the region.

## Methods

### Data and sample

We analyzed data from the Chronic Disease Risk Factor (CDRF) study, a cross-sectional survey conducted at rural South Asian sites around Goa and Chennai in India and Matlab in Bangladesh ($n = 3704$). These sites were chosen to represent typical rural communities in their settings with respect to access to healthcare facilities and demographic characteristics such as occupation and socioeconomics. At each site, households in consecutive village sections, from the health care center onwards, were sampled until households numbered more than 250 and all included sections were fully sampled ($n = 309$ families in Goa, 257 families in Chennai and 308 families in Matlab) (Millett et al. 2013). Chennai and Goa are coastal sites and Matlab is located by a riverside. Despite their geographical differences, the sites were selected due to their rural context with connectivity to health facilities. Residents who had lived in the area for more than 6 months of the year were invited to participate ($n = 1212$ in Goa, 940 in Chennai and 1143 in Matlab). We analyzed data from 2271 adult (ages 18 years and above) respondents, with 669 in Chennai, 745 in Matlab and 857 in Goa (Table 1). Study response rates were high, ranging from 93 to 96%. The study was led by investigators in collaboration with civil society partners including Voluntary Health Services (Chennai), Sangath (Goa) and the International Centre for Diarrheal Disease Research, Bangladesh (ICDDRB, Bangladesh). The study received ethical approval from institutional ethics committees at partner organizations and as well as Health Ministry Screening Clearance by Government of India (No. 50/5/Indo-CVD/DP/2010-NCD-II).

### Data collection

Data were collected between June 2011 to May 2012 in Matlab and between October 2011 and March 2013 in Goa and Chennai. Trained field investigators conducted house-to-house interviews using structured questionnaires in the

**Table 1** Sociodemographic characteristics of respondents (adult) in the Chronic Disease Risk Factor (CDRF) study in India and Bangladesh (2011–2013)

| | Bangladesh | India | |
|---|---|---|---|
| | Matlab | Goa | Chennai |
| Respondents (total) (in numbers) | 1143 | 1212 | 940 |
| Respondents (18+ years) (in numbers) | 745 | 857 | 669 |
| Gender (in %) | | | |
| Male | 40.4 | 43.4 | 48.1 |
| Female | 59.6 | 56.6 | 51.9 |
| Mean age (in years) | 41.4 | 40.5 | 37.2 |
| Age categories (in %) | | | |
| 18–35 | 40.3 | 37.6 | 48.1 |
| 35–55 | 39.3 | 42.8 | 36.5 |
| 55+ | 20.4 | 19.6 | 15.4 |
| Education level (in %) | | | |
| None | 24.2 | 25.7 | 32.1 |
| Primary | 26.4 | 33.6 | 19.8 |
| Secondary | 44.5 | 35.4 | 41.2 |
| Higher | 4.8 | 5.3 | 6.9 |
| Wealth tertile (in %) | | | |
| Low | 28.6 | 16.9 | 45.4 |
| Medium | 28.5 | 29.6 | 33.5 |
| High | 28.3 | 48.8 | 12.3 |
| Occupation (in %) | | | |
| Manual (unskilled) | 11.9 | 34.3 | 49.9 |
| Manual (skilled) | 10.6 | 6.5 | 9.8 |
| Non-manual (professional) | 13.7 | 12.4 | 6.0 |
| Others | 63.8 | 46.7 | 34.3 |

local language of the area. Data on sociodemographics, chronic disease history and risk factors were collected. We analyzed data for seven chronic conditions and six behavioral risk factors.

The seven chronic conditions included being overweight/obese, diabetes, hypertension, impaired lung function, vision impairment, disability score and depression score (details of measurement in supplementary Table 1). We estimated overweight and obesity if BMI (in kg/m$^2$) was greater than 25 kg/m$^2$ (global standard) using measured height and weight from respondents. We estimated diabetes if fasting glucose levels (in mg/dL) were greater than 126 mg/dL, and if respondents reported weekly or daily medication for diabetes. Data on glucose were not available in Matlab. We estimated hypertension if systolic blood pressure (BP) was greater than 140 mmHg and diastolic BP was greater than 90 mmHg or if respondents reported weekly or daily medication for hypertension. We measured lung function using a ratio of force expiratory volume in 1 s (FEV1) and forced vital capacity (FVC). Respondents with the ratio less than 0.7 were classified as having impaired lung function (Hankinson et al. 1999). We estimated impaired vision using a visual acuity test. Low vision for each eye was considered as ≤6/24 on the Snellen's chart. We excluded data from Matlab as information on spectacle use was not available. We estimated moderate to severe disability using the WHO Disability Assessment Schedule II for physical and mental health disabilities (WHO undated). We estimated moderate to severe depression using the Patient Health Questionnaire (PHQ-9) (Kroenke et al. 2001).

The six behavioral risk factors including fruit and vegetable consumption, physical activity, current smoking (overall and separately for cigarette and beedi), current chewed tobacco use and harmful use of alcohol. We estimated rates of one fruit a day and two vegetables a day using self-reported fruit–vegetable consumption and daily servings. We estimated self-reported work or recreational vigorous physical activity (defined as 'vigorous-intensity activity that causes large increases in breathing or heart rate for at least 10 min continuously') using the Global Physical Activity Questionnaire (WHO undated). We estimated current smoking overall and current smoking of cigarettes and beedis, current chewed tobacco use and harmful use of alcohol for male respondents only. Current use of tobacco was self-reported and harmful use of alcohol (hazardous use and alcohol dependence) was measured using the Alcohol Use Disorder Identification Test (AUDIT) scale (Saunders et al. 1993; Babor et al. 1989).

### Covariates

We collected data on sociodemographic aspects including sex, age, education, occupation and wealth. We classified education into three categories including respondents with no formal education, primary education and secondary or higher levels of education. We categorized occupation into manual (skilled or unskilled), non-manual skilled or professional and others (including those at home). We estimated wealth tertiles at the India sites using data on expenditure on basic family items available monthly or yearly. Consumption expenditure is a frequently used technique that estimates wealth in settings in South Asia where data on incomes are unreliable. In light of this, socioeconomic status is often measured using assets or consumption. In this study, data were available on five key items included food, electricity, clothing, phone and soap. Consumption expenditure has been used in studies using the National Sample Surveys in India (Garg and Karan 2009; Bhan et al. 2016). For Matlab, we estimated wealth from an asset score using principal components analysis (PCA) and categorized into tertiles (Vyas and Kumaranayake 2006; Howe et al. 2008). Asset scores have been used globally by large-scale surveys [demographic and health surveys (DHS)] to estimate and compare wealth across contexts. Tertiles estimated at the India and Bangladesh sites were merged for analysis.

### Analysis

We estimated prevalence of overweight, hypertension, high glucose, impaired lung function and vision, moderate to severe disability, depression and rates of fruit and vegetable use for all respondents across socioeconomic groups. We estimated current cigarette and beedi use, current chewed tobacco use and harmful use of alcohol for male respondents across socioeconomic groups. We estimated age–sex and site-adjusted Odds Ratios (and 95% CIs) for all outcomes by wealth tertiles, education and occupational groups. Analyses were conducted in STATA 13.

## Results

The study sample comprised 2271 respondents with high participation of women in Matlab (59.6%) and Goa (56.6%) (Table 1). Matlab and Goa were similar in their educational profile. About 50% of the respondents in Chennai were engaged in unskilled manual work compared to 12% in Matlab. Only 6% of the respondents in Chennai were engaged in skilled non-manual work.

### Chronic conditions and risk factors

Rates of overweight (20.9%), hypertension (20.3%) and diabetes (10.8%) were high in Goa (Table 2). About 10% reported impaired lung function in Chennai (9.8%). Chennai reported higher rates (16.6%) of moderate to severe depressive symptoms (PHQ-9 $> 9$) compared to Matlab (3.4%) and Goa (2.9%). Consumption of fruits was greater in Goa and vegetable consumption was higher in Matlab. Rates of vigorous physical activity were higher in Chennai (46.1%). Chewed tobacco use was greater among men in the India sites (Chennai (61.9%) and Goa (46.7%)). Harmful alcohol use (AUDIT $\geq 16$) was higher in Goa (8.9%) compared to Chennai (5.2%).

### Fruit and vegetable consumption

Rural residents with higher education were twice as likely to consume one-fruit-a-day [OR = 1.93 (95% CI 1.4,2.6)] and two vegetables a day [OR = 1.89 (95% CI 1.48,2.4)] (Table 3; Fig. 1) compared to rural residents with no education. Respondents with greater wealth were more likely to consume fruit [OR = 3.61 (95% CI 2.7,4.8)]. Non-manual workers were almost three times as likely to consume two-vegetables-a day [OR = 2.9 (95% CI 2.2,3.9)] compared to manual workers.

### Vigorous physical activity

Rural residents with higher education were almost half as likely to report vigorous physical activity [OR = 0.52 (95% CI 0.39,0.69)] than those with no education. Wealthier respondents reported lower vigorous physical activity [medium wealth tertile = 0.68 (95% CI 0.53,0.87)] and highest wealth tertile = 0.48 (95% CI 0.37,0.63)]. Compared to manual workers, non-manual workers reported lower likelihood of vigorous physical activity [OR = 0.38 (95% CI 0.27,0.54)].

### Tobacco and alcohol use

Rural residents with higher education reported lower likelihood of cigarette [OR = 0.59 (95% CI 0.38,0.92)], beedi [OR = 0.16 (95% CI 0.08,0.33)] and harmful alcohol use [OR = 0.4 (95% CI 0.24,0.67)] (Fig. 1). Respondents with greater wealth reported lower tobacco and alcohol use, with trends being sharper for beedi [OR = 0.29 (95% CI 0.15, 0.56) and alcohol use [OR = 0.21 (95% CI 0.13,0.34). Compared to manual workers, non-manual workers were less likely to report chewing tobacco [OR = 0.4 (95% CI

**Table 2** Prevalence (95% CIs) of Common Chronic Conditions and Behavioral Risk Factors in the Chronic Disease Risk Factor (CDRF) study in India and Bangladesh (2011–2013)

| | Matlab, Bangladesh | Goa, India | Chennai, India |
|---|---|---|---|
| Health outcomes | | | |
| Overweight and obesity (global standard, body mass index (BMI) $\geq$ 25 kg/m$^2$) | 14.8 (12.2, 17.3) | 20.9 (18.0, 23.9) | 17.5 (14.6, 20.5) |
| High risk for hypertension [systolic blood pressure (SBP) $\geq$ 140 mmHg and diastolic blood pressure (DBP) $\geq$ 90 mmHg] or who report hypertension along with daily or weekly medication use | 11.7 (9.4, 14.0) | 20.3 (17.4, 23.2) | 9.8 (7.4, 12.1) |
| High risk for diabetes (glucose > 126 mg/dL) or who report diabetes along with daily or weekly medication use | – | 10.8 (8.5, 13.1) | 6.6 (4.6, 8.6) |
| Impaired lung function [forced expiratory volume in 1 s (FEV1)/forced vital capacity (FVC) < 0.7] | 4.6 (3.0, 6.1) | 4.4 (3.05, 5.8) | 9.8 (7.6, 12.1) |
| Impaired vision (vision in each eye $\leq$ 6/24 without spectacles) | – | 15.0 (12.6, 17.4) | 15.8 (13.1, 18.6) |
| Moderate to severe disability (WHO disability assessment schedule (DAS) > 25) | 3.4 (1.9, 4.9) | 0.9 (0.2, 1.6) | 3.6 (1.6, 5.5) |
| Moderate to severe depression [patient health questionnaire (PHQ)-9 $\geq$ 10] | 3.4 (2.1, 4.7) | 2.9 (1.8, 4.1) | 16.6 (13.7, 19.4) |
| Risk factors | | | |
| Consuming one fruit a day | 13.4 (10.9, 15.9) | 36.4 (33.2, 39.6) | 5.8 (4.05, 7.6) |
| Consuming two vegetables a day | NE | 21.5 (18.7, 24.2) | 18.4 (15.4, 21.3) |
| Self-reported work or sports related physical activity [leading to large increases in breathing or heart rate of at least 10 min as per the Global Physical Activity Questionnaire (GPAQ)] | 12.6 (10.2, 15.0) | 17.9 (15.4, 20.5) | 46.1 (42.3, 49.9) |
| Current smoking (overall, men only) | 44.2 (38.5, 49.8) | 14.3 (10.7, 17.8) | 27.6 (22.7, 32.5) |
| Current cigarette use (overall, men only) | 41.8 (36.3, 47.4) | 11.3 (8.08, 14.5) | 13.9 (10.2, 17.8) |
| Current beedi use (overall, men only) | 2.3 (0.6, 4.03) | 5.7 (3.3, 8.04) | 18.1 (13.9, 22.3) |
| Current chewed tobacco use (overall, men only) | 26.2 (21.2, 31.2) | 46.7 (38.4, 55.1) | 61.9 (54.9, 68.8) |
| Harmful alcohol use (men only) (alcohol use disorders identification test $\geq$ 16), men only | – | 8.9 (5.9, 11.8) | 5.2 (4.6, 5.7) |

Details on each measure in supplementary Table 1

*NE* not estimated as almost the entire population reported consuming 2 vegetables a day at this site

0.26,0.62) and alcohol use [OR = 0.37 (95% CI 0.21,0.66)]. Differences in cigarette use by occupation of respondents were not statistically significant.

### Overweight, hypertension and diabetes

Rural residents with higher education were more likely to be overweight [OR = 1.81 (95% CI 1.31,2.51) (Table 4; Fig. 2) than rural residents with primary education. Associations between education and hypertension were unclear. Higher educated respondents were also more likely to have diabetes. Compared to the poorest respondents, those in the middle and highest wealth tertiles were more likely to be overweight [middle tertile, OR = 1.6 (95% CI 1.19,2.28) and highest tertile, OR = 2.48 (95% CI 1.8,3.38)] and have diabetes [middle tertile, OR = 2.2 (95% CI 1.28,3.8) and highest tertile, OR = 2.17 (95% CI 1.25,3.75)]. Wealthier respondents were more likely to have hypertension [OR = 1.6 (95% CI 1.15,2.23)]. Compared to manual workers, non-manual work was associated with greater odds of having diabetes [OR = 1.88 (95% CI 1.02,3.5)] and overweight [OR = 2.28 (95% CI 1.6,3.3)].

### Disability, lung function and depression

Rural residents with higher education showed lower odds of vision impairment [OR = 0.51 (95% CI 0.31,0.84)] than those with primary education. Similarly, wealthier

**Table 3** Socioeconomic differences in age–sex–site adjusted odds ratios (95% CIs) for Behavioral Risk Factors in the Chronic Disease Risk Factor (CDRF) study in India and Bangladesh (2011–2013)

| | One or more fruit servings per day | Two or more vegetables servings per day | Vigorous physical activity | Current cigarette use | Current beedi use | Current tobacco chewing | Harmful alcohol use |
|---|---|---|---|---|---|---|---|
| Education | | | | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Primary | 1.56* (1.13, 2.15) | 1.41* (1.11, 1.81) | 0.68* (0.51, 0.90) | 1.19 (0.78, 1.8) | 0.65 (0.38, 1.1) | 0.77 (0.5, 1.2) | 0.44* (0.27, 0.74) |
| Secondary and higher | 1.93* (1.40, 2.64) | 1.89* (1.48, 2.41) | 0.52* (0.39, 0.69) | 0.59* (0.38, 0.92) | 0.16* (0.08, 0.33) | 1.04 (0.68, 1.6) | 0.40* (0.24, 0.67) |
| Wealth tertiles | | | | | | | |
| Low | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Medium | 1.50* (1.1, 2.06) | 1.01 (0.82, 1.26) | 0.68* (0.53, 0.87) | 0.85 (0.57, 1.26) | 0.7 (0.41, 1.2) | 1.07(0.72, 1.6) | 0.62* (0.41, 0.93) |
| High | 3.61* (2.71, 4.82) | 1.13 (0.92, 1.41) | 0.48* (0.37, 0.63) | 0.65* (0.44, 0.98) | 0.29* (0.15, 0.56) | 0.62* (0.41, 0.94) | 0.21* (0.13, 0.34) |
| Occupation | | | | | | | |
| Manual worker | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-manual skilled | 2.04 (1.5, 2.8) | 2.9* (2.2, 3.9) | 0.38* (0.27, 0.54) | 1.45 (0.99, 2.09) | 0.18* (0.06, 0.52) | 0.4* (0.26, 0.62) | 0.37* (0.21, 0.66) |
| Others | 1.2* (0.9, 1.5) | 2.7* (2.2, 3.4) | 0.40* (0.32, 0.52) | 0.51* (0.32, 0.79) | 0.54*(0.29, 0.98) | 0.4* (0.26, 0.64) | 0.45* (0.28, 0.7) |

Details for measures in supplementary Table 1

We adjusted for age, sex and site to keep the models parsimonious and focus the analysis on SES differences

* Statistical significance at 5% level

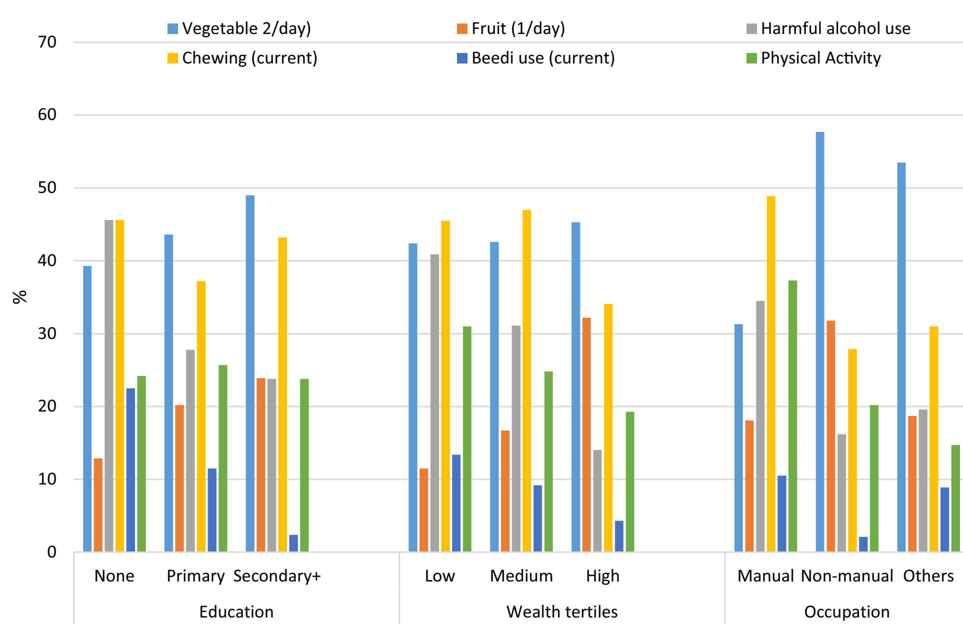


**Fig. 1** Distribution of key behavioral risk factors by occupation, wealth and education in the Chronic Disease Risk Factor (CDRF) study in India and Bangladesh (2011–2013)

**Table 4** Socioeconomic differences in age–sex–site adjusted odds ratios (95% CIs) for Chronic Conditions in the Chronic Disease Risk Factor (CDRF) study in India and Bangladesh (2011–2013)

| | Overweight | Hypertension | Diabetes | Vision impairment | Impaired lung function | Moderate- severe depression | Moderate to severe disability |
|---|---|---|---|---|---|---|---|
| Education | | | | | | | |
| None | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Primary | 1.09 (0.78, 1.54) | 0.94 (0.67, 1.34) | 1.65 (0.97, 2.8) | 0.68 (0.46, 1.02) | 0.96 (0.61, 1.49) | 0.55* (0.36, 0.86) | 0.37 (0.13, 1.04) |
| Secondary and higher | 1.81* (1.31, 2.51) | 1.07 (0.75, 1.52) | 1.84* (0.99, 3.4) | 0.51* (0.31, 0.84) | 0.63 (0.39, 1.04) | 0.41* (0.25, 0.66) | 0.56 (0.22, 1.45) |
| Wealth tertiles | | | | | | | |
| Low | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Medium | 1.65* (1.19, 2.28) | 1.08 (0.77, 1.5) | 2.2* (1.28, 3.8) | 0.74 (0.49, 1.10) | 0.93 (0.61, 1.44) | 0.68 (0.46, 1.01) | 1.21 (0.55, 2.67) |
| High | 2.48* (1.82, 3.38) | 1.6* (1.15, 2.23) | 2.17* (1.25, 3.75) | 0.77 (0.52, 1.13) | 0.70 (0.44, 1.11) | 0.38* (0.24, 0.59) | 0.55 (0.23, 1.34) |
| Occupation | | | | | | | |
| Manual worker | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-manual skilled | 2.28* (1.6, 3.3) | 1.37 (0.89, 2.1) | 1.88* (1.02, 3.5) | 0.74 (0.44, 1.26) | 0.99 (0.57, 1.75) | 0.58 (0.29, 1.15) | 3.12 (0.43, 22.4) |
| Others | 1.01 (0.77, 1.34) | 1.2 (0.87, 1.65) | 1.13 (0.72, 1.77) | 0.90 (0.65, 1.25) | 0.83 (0.54, 1.26) | 0.74 (0.51, 1.07) | 23.7* (5.3, 105.9) |

Details for measures in supplementary Table 1

We adjusted for age, sex and site to keep the models parsimonious and focus the analysis on SES differences

* Statistical significance at 5% level

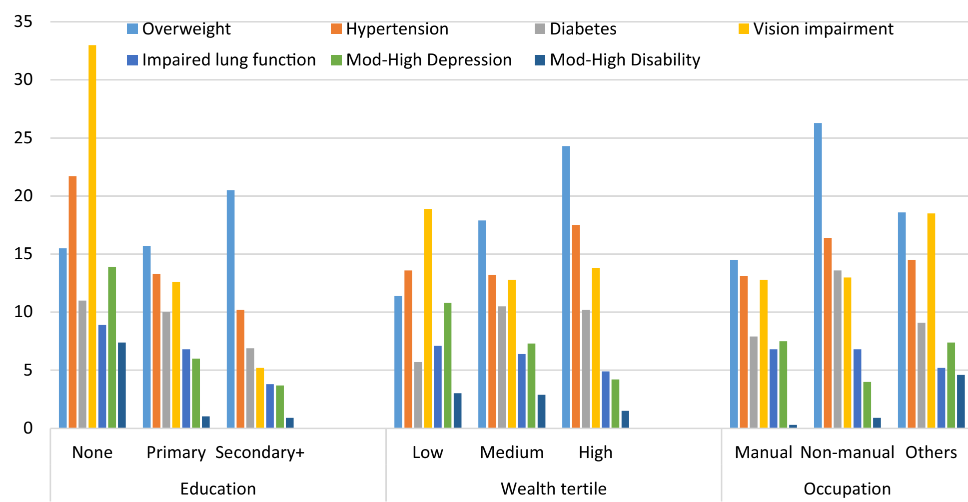


**Fig. 2** Prevalence of key chronic conditions by occupation, wealth and education in the Chronic Disease Risk Factor (CDRF) study in India and Bangladesh (2011–2013)

respondents may have shown lower impairments of vision and lung function as estimates were not statistically significant. Differences between manual and non-manual workers in vision impairment, lung function and depression were not statistically significant. Respondents with higher education and wealth reported lower moderate to severe depression [secondary education, OR = 0.41 (95% CI 0.25,0.66) and highest wealth tertile, OR = 0.38 (95% CI 0.24,0.59)].

## Discussion

In this study, we found variation in the burden of chronic conditions across rural sites in South Asia. The relationship between socioeconomic status and chronic conditions was multidimensional, varying by risk pathways and marker of SES. We show three salient findings. First, we found that wealthier rural residents were more likely to be overweight, and have hypertension and diabetes. However, when chronic disease risk factors were considered, evidence was mixed, with wealthier respondents reporting higher fruit consumption but lower physical activity. Second, rural respondents with higher education reported lower tobacco and alcohol use, and higher fruit–vegetable consumption, which may protect against chronic conditions. However, rural respondents with higher education also reported lower physical activity. Finally, we found that the type of work exposed respondents to risks of chronic conditions. Non-manual workers were more likely to be overweight and have diabetes, and reported lower physical activity, tobacco and alcohol use. These findings highlight the multi-dimensionality and complexity in the risk factor pathways linking SES to chronic conditions. For instance, education may be linked to chronic conditions through awareness of healthy behaviors and risks, but may also influence behaviors due to an income effect on affording healthy foods (fruits–vegetables) and leisure time (less vigorous physical activity). Results, thus, highlight the need to further investigate each of these pathways in-depth.

This study further establishes that chronic diseases are not only an urban issue in South Asia but are increasingly impacting rural communities, which may be more vulnerable due to lack of health infrastructure to deal with this burden. In this study, we found high risks of chronic conditions across these sites, which is consistent with newly published nationally representative data. The recently released National Family Health Survey (NFHS) IV data shows that one-fourth of the populations in rural Goa and Chennai are overweight or obese (IIPS Tamil Nadu undated, IIPS Goa undated). Additionally nearly 6 and 4% of the populations in Goa and Tamil Nadu, respectively, reported high blood glucose (IIPS Tamil Nadu undated, IIPS Goa undated). Tobacco and alcohol use rates in India, particularly in rural settings, continue to be high. Tobacco use among rural men in India varies from 18.6% in Goa and 31.2% in Tamil Nadu, while any alcohol use is around 48% in both states (IIPS Tamil Nadu undated, IIPS Goa undated). These high rates show that concentrating chronic disease interventions in urban settings can miss out the high and rising burden of these conditions in rural areas, where the majority of Indian and other south Asian populations currently reside.

Our findings, based on measurements and reported data using validated instruments, also address concerns about differences between measured versus self-reported outcomes (Vellakkal et al. 2013). Our results resonate with studies on inequities in chronic disease risk factors (Bhan et al. 2016; Jeemon and Reddy 2010; Millett et al. 2013; Subramanian et al. 2005). The debate on the direction of the relationship between SES and chronic diseases needs to be strengthened by careful disaggregation of inequities based on an etiological understanding of pathways that link SES to health such as awareness (linked to education), affordability (linked to incomes) and nature of work (linked to occupations) (Subramanian et al. 2013; Reddy et al. 2005; Prabhakaran et al. 2013). For example, inequalities in lung function may be distributed by risks such as smoking, indoor air pollution and transport-related pollution across socioeconomic groups (Ingle et al. 2005; Smith et al. 1983). Hence interventions to improve inequities in chronic conditions need to be targeted towards these specific risk pathways.

India, recently launched the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Disease and Stroke (NPCDCS) and the National Mental Health Policy (2014) (GOI 2008, 2014). Similarly, Bangladesh has listed chronic conditions as a priority emerging health challenge (Bleich et al. 2011). As policies are being designed and implemented, evidence on vulnerabilities linked to chronic conditions and risk factors will strengthen interventions for prevention and management. This is even more urgent for rural settings in South Asia where health services for chronic conditions are unprepared and inadequate to deal with this disease burden.

Findings from this study need to be considered in light of some constraints. First, despite common protocols across sites, data on glucose, visual acuity and alcohol were not available in Matlab, Bangladesh. Hence inferences for these outcomes are based on India data only. Second, India and Bangladesh sites used different methodology for data on wealth. At the India site, wealth was assessed using consumption expenditure on key household items and while in Matlab, an asset score was generated. Both methods are considered valid and extensively used. We combined wealth tertiles separately created for India and Bangladesh for final analysis. Third, categories of wealth and education are ordered, while occupation categories represent qualitative differences in the nature of work (manual versus non-manual). This needs to be considered in inferences about the direction of the relationships between SES and chronic diseases. Fourth, there is limited power to address SES differences within study sites, which were purposively sampled to be representative of the rural populations residing in these areas. Finally, while the sites are similar in major characteristics which were the reason for their selection, there is some geographic heterogeneity across the three locations. This contextual factor along with historical and cultural factors may influence differences in estimates across sites. At present, we are able to adjust for site but not present a stratified analysis of the relationship. We present a composite picture of the relationship, adjusting for unique site differences and cannot investigate specific mechanisms within sites. Future studies with larger samples and greater study power can disentangle these site-specific effects.

## Conclusion

This study from rural sites in South Asia showed that markers of socioeconomic status (wealth, occupation and education) have diverse relationships across chronic conditions and risk factors. These relationships are specific to risk factors, pathways and sociodemographic contexts. In light of this, ongoing monitoring of inequalities in chronic diseases and their risk factors is important in the planning and evaluation of interventions to address their growing burden in rural south Asia.

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### Compliance with ethical standards

**Conflict of interest** All authors declare that they have no conflict of interest.

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