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RESEARCH ARTICLE

Variations in adult BMI among Indian men: a quantile regression analysis

Archana Agnihotri and Brinda Viswanathan

Madras School of Economics, Kotturpuram, Chennai 600025, TN, India
Corresponding author: Archana Agnihotri; Email: archie2595@gmail.com

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Abstract

India has not only maintained its top position among countries with the largest number of underweight adults but has also jumped to a higher position among countries with largest increase in the proportion of overweight people in the last three decades. More studies focus on double burden of malnutrition among women than on men. This study uses the quantile regression model to analyse the covariates associated with low and high body mass index (BMI) primarily among men aged 20–54 years during 2015–2016 in India. Occupations that involve more manual work help in maintaining a normal BMI along with better education, dietary diversity, and less sedentary lifestyle. A gendered comparison of men and their spouses highlights the differences in the association of covariates with BMI for men and women. The results from this study will provide insights for behavioural change at an individual level and inputs for public health intervention for addressing ill health concerns arising from underweight, overweight, or obesity.

Keywords: population health; education; demography

JEL Codes: I10; I20; J10

Introduction

India's transition from a low-income country to a middle-income during the last three decades has resulted in more economic inequality (Piketty *et al.*, 2022). Those on the lower end of the economic strata are vulnerable to nutrient deficiencies and show high rates of undernutrition. Among the non-poor, overweight and obesity rates are on the rise due to more sedentary lifestyles combined with improved availability and affordability of more energy-dense and sweetened food items (Black *et al.*, 2013). India is among the countries with the largest number of underweight adults, and in the last three decades has jumped to a higher position among countries with the largest increase in the proportion of overweight people ((NCD Risk Factor Collaboration (NCD-RisC), 2017). This coexistence of a substantial number of undernourished as well as overweight and obese people referred to as double burden of malnutrition is becoming the focus of public health intervention (Viswanathan and Agnihotri, 2020). In the more recent decade from 2005 to 2015, the changes in double burden are shifting more towards overweight and obesity rates among men from 9.3% to 18.9% when compared to women (IIPS, 2017). Between 2015 and 2020, the overweight and obesity rates increased further to 22.9% among men (IIPS, 2021). The decline in underweight rates during this period is impressive, from 20.2% to 16.2%, but the number of underweight men is still large due to India's huge population base.

Body mass index (BMI) is a commonly used indicator of double burden of malnutrition at a geographical level of disaggregation (Ackerson *et al.*, 2008). BMI is the ratio of weight (in kilograms) to squared height (in metres) and is a useful marker for assessing the risk to disease burden for public health interventions (Luke *et al.*, 2021). In order to reduce the burden on public resources, it is important to focus on factors that simultaneously address ill health concerns arising from being underweight and overweight or obese. Behavioural and lifestyle changes at an individual level through awareness for improving personal hygiene and health would reduce the stress on public and private expenditure from disease prevention. From this standpoint, this study makes a few additions to the literature.

The first contribution of this study is that it focuses on adult men. Most studies on malnutrition in developing countries focus on women, as the disparities and deprivations are large among them with implications for intergenerational transmission and hence calls for a public policy intervention (Young *et al.*, 2020). However, not providing adequate evidence on men would ignore health challenges that are biologically, socially, and economically different between the two genders. Further, men have a larger say in the household decision-making related to health, consumption spending, and dietary habits in the Indian context (Evans *et al.*, 2022). Hence, understanding the factors associated with malnutrition among men can result in policies that are bundled to cater to the needs of the whole family.

The second contribution of this study is to focus on a few individual-level covariates of BMI viz. occupation, education, lifestyle, and dietary habits, while controlling other individual, household, and regional covariates as permitted by the data. Individual level data are rather challenging and time-consuming to collect, and the nationally representative National Family Health Survey is one such rare data source for India with rich information on lifestyle habits, dietary quality, along with nutritional, health, and occupational status (IIPS, 2017).

The third contribution of this study is to use the statistical technique of quantile regression that provides estimates of the covariates, which vary across the BMI distribution (Koenker, 2005). It allows for a simultaneous comparison of the extent of differences in the association of covariates among the undernourished (underweight), the well-nourished, and the over-nourished (overweight and obese), and is thus more realistic to capture individual behaviour and will also be policy-relevant to address the double burden of malnutrition.

A fourth contribution of this study is to compare men and women who are couples and hence from the same family to examine if the covariates that are available for both men and women have a similar pattern of association. When there are gender differences, we further discuss the possible reasons for these and thereby emphasise the need for gender-specific data collection to inform health policy planning.

Materials and methods

Data source

The empirical analysis is based on the nationally representative fourth National Family Health Survey (NFHS-4) conducted from 2015 to 2016 across all 29 states and 7 Union Territories in India. Cross-sectional data on demographic, anthropometric, socioeconomic, and health information are collected from a sample of 699,686 women (15–49 years) and 112,122 men (15–54 years) from 601,509 households. Sampling technique is the two-stage stratified random sampling with the primary sampling units divided into two main strata – rural (villages) and urban (wards/municipal localities) – and are drawn separately based on the relative sizes of the state and of the urban and rural populations within the state.

Outcome variable

The survey data provide the height (in centimetres), weight (in kilograms), as measured during the survey of adult men and women, and BMI (units in kg/m^2), constructed as weight/(height)^2, as the nutritional outcome variable. The lower age limit is restricted to 20 years as adult height stabilises

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by this age and upper age limit is restricted to 54 (49) years for men (women) as provided in the database. Thus, conditional on height, BMI measures the variations in weight which in turn reflects the net of an individual's energy expenditure after accounting for basal metabolic rate, dietary intake, physical activity, climatic, and health conditions (Shetty and James, 1994). The (weighted) mean from a sample of 89,374 men aged 20–54 years for BMI is 22.4 kg/m^2.

Due to a large difference in the sample size for the men and women (525,454), we additionally compare results with women (excluding those who are pregnant for four or more months); and with a smaller sample of married men and their wives, both of whom are surveyed from the same household. The (weighted) mean from this couple sample of 56,429 men aged 20–49 years for BMI is 22.6 kg/m^2; the upper age limit is lower here as per the age limit for women's sample in the database.

Description of covariates

Physical activity accounts for metabolic activity and energy expenditure and hence affects BMI. In the absence of direct information on physical activity data, occupation groups reflecting manual or sedentary nature of work is a relevant proxy (Dang *et al*., 2019). The occupational codes assigned to the employed men are as per the National Classification of Occupations (2008) and grouped into broadly four levels of physical activity intensity in their occupations as in Agnihotri and Viswanathan (2021). The job (henceforth, job and occupation will be used interchangeably) categories, as detailed in Table 1, show that *not working*, *more sedentary*, and *less sedentary* account for between 8% and 10% each; 69% men are in *active manual* jobs and *other* jobs are 4%.

Age has a non-linear relationship with BMI (Ramachandran and Kalaivani, 2018) so age and squared age are both included as covariates. The average age is about 35 years in the full sample and 38 years in the couple sample. The years of education available from the data are categorised as shown in Table 1. About 30% of men have 12 or more years of education with the next highest share for 8–9 years of education.

The information on dietary habits of an individual in NFHS-4 is collected based on the food frequency from weekly consumption of milk or curd, pulses or beans, dark green leafy vegetables, fruits, eggs, fish, chicken, or meat. Based on Agrawal *et al.* (2014), the categories of dietary habits described in Table 1 show that the preference for non-vegetarian and lacto-vegetarians is equally distributed (31%), while 11% prefer vegan diet and the remaining food groups – semi-vegetarian, pesco-vegetarian, and lacto-ovo vegetarian – each account for between 8% and 10%. Four other consumption habits affecting metabolic activity considered separately are as follows: either daily or weekly intake of fried food, aerated drinks, alcohol, and tobacco, reported by 45%, 30%, 34%, and 35% of men, respectively.

Table 1 also summarises several other covariates. Frequency of watching television (TV)- daily (62%) or less frequently; possession of mobile phone (94%); and type of vehicle (non-motor, bike, and car) used for transportation (45%) are covariates used to capture sedentary/non-sedentary lifestyle habits as they are known to be associated with higher BMI. Access to health care, hygienic practices, marital status, caste, religion, economic status based on asset quintile of the household, household composition, and geographic factors like state of residence, urban or rural, are included as covariates based on their importance in explaining BMI from earlier studies.

Statistical analysis: quantile regression model

When all the individuals are ranked by their BMI, an individual is at the q^{th} quantile of BMI, if there are q fraction of individuals with lower BMI values and $(1-q)$ fraction are at higher values. For instance, 0.6^{th} quantile indicates that 0.6 fraction or 60% of individuals have BMI less than this individual and 40% have more BMI values. We expect that the different factors (covariates)

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Table 1. Descriptive Statistics

Variable	Full Sample (N: 89,374) Mean	Full Sample (N: 89,374) Standard Deviation	Couple Sample (N: 56,429) Mean	Couple Sample (N: 56,429) Standard Deviation
BMI (Kg/m^2)	22.38	3.6	22.64	3.65
Not working	0.08	0.28	0.02	0.15
More sedentary jobs	0.09	0.29	0.09	0.29
Less sedentary jobs	0.10	0.29	0.1	0.29
Active manual jobs	0.69	0.46	0.74	0.44
Other jobs	0.04	0.2	0.04	0.2
Age (Years)	34.85	9.69	37.73	8.52
Squared age (Years)	1308.25	702.27	1496.37	648.46
No schooling	0.15	0.36	0.18	0.38
1–4 years of education	0.07	0.26	0.08	0.28
5–7 years of education	0.15	0.36	0.17	0.37
8–9 years of education	0.18	0.38	0.19	0.39
10–11 years of education	0.14	0.35	0.15	0.35
≥12 years of education	0.30	0.46	0.23	0.42
Non-vegetarian	0.31	0.46	0.31	0.46
Semi-vegetarian	0.1	0.3	0.1	0.3
Pesco-vegetarian	0.09	0.28	0.09	0.29
Lacto-ovo vegetarian	0.08	0.28	0.08	0.27
Lacto-vegetarian	0.31	0.46	0.31	0.46
Vegan	0.11	0.32	0.12	0.32
Fried food	0.45	0.5	0.44	0.5
Aerated drinks	0.3	0.46	0.28	0.45
Alcohol	0.34	0.47	0.36	0.48
Tobacco	0.35	0.48	0.36	0.48
Everyday TV watching	0.62	0.49	0.6	0.49
Mobile	0.95	0.21	0.95	0.22
Non-motor transport	0.52	0.5	0.53	0.5
Bike	0.41	0.49	0.4	0.49
Car	0.07	0.25	0.07	0.25
Currently married	0.76	0.43		
Formerly married	0.02	0.13		
Never married	0.22	0.41		
Poorest	0.14	0.35	0.16	0.37
Poorer	0.18	0.39	0.19	0.39
Middle	0.21	0.41	0.21	0.41
Richer	0.22	0.42	0.22	0.41
Richest	0.23	0.42	0.22	0.42

(*Continued*)

Table 1. (*Continued*)

Variable	Full Sample (N: 89,374)		Couple Sample (N: 56,429)	
	Mean	Standard Deviation	Mean	Standard Deviation
Hindu	0.82	0.38	0.82	0.38
Muslim	0.12	0.33	0.12	0.33
Christian	0.02	0.15	0.02	0.15
Sikh	0.02	0.13	0.02	0.12
Jain	0.002	0.04	0.002	0.04
Other religions	0.01	0.11	0.01	0.11
Don't know the caste	0.05	0.23	0.05	0.22
SC	0.2	0.4	0.2	0.4
ST	0.09	0.29	0.1	0.29
OBC	0.44	0.5	0.44	0.5
Other castes	0.24	0.43	0.23	0.42
Open defecation	0.35	0.48	0.37	0.48
Visit hospital	0.09	0.29	0.1	0.3
No insurance	0.76	0.43	0.74	0.44
Public insurance	0.21	0.41	0.23	0.42
Private insurance	0.01	0.12	0.02	0.12
Employer insurance	0.02	0.13	0.02	0.13
No of persons in house	5.46	2.6	5.57	2.51
Share of young children	0.09	0.13	0.1	0.14
Share of old children	0.13	0.17	0.16	0.18
Share of teen females	0.06	0.11	0.06	0.11
Share of teen males	0.06	0.11	0.06	0.11
Share of adult males	0.29	0.12	0.29	0.11
Share of adult females	0.35	0.18	0.29	0.12
Share of elder males	0.02	0.06	0.02	0.05
Share of elder females	0.02	0.06	0.02	0.05
Urban	0.38	0.48	0.35	0.48
North	0.09	0.29	0.09	0.28
Central	0.26	0.44	0.26	0.44
West	0.18	0.39	0.17	0.38
South	0.24	0.43	0.25	0.43
East	0.19	0.39	0.2	0.4
North East	0.03	0.18	0.03	0.18

Source: Author's own calculation. Notes: (1) All the means are proportions except BMI, age, and squared age. (2) Occupation variables: (a) *not working* and are students enrolled in colleges, unemployed, and the retired; (b) *more sedentary* and are white collared professionals in technical, executive, managerial, or clerical work; (c) *less sedentary* and are sales, service, transport, or communications workers; (d) *active manual* and are farmers, loggers, carpenters or miners, factory workers, and other similar blue-collared workers; and *others* who have no occupation codes but are active in the labour market. (3) The years of education available from the data are categorised into, 0 (no schooling), 1–4, 5–7, 8–9, 10–11, or 12 or more years. (4) Dietary Habits: *Non-vegetarian*: milk, pulses, vegetables, fruits, eggs, fish, or chicken; *Semi-vegetarian*: milk, pulses, vegetables, fruits, eggs or chicken, and no fish; *Pesco-vegetarian*: milk, pulses, vegetables, fruits, eggs or fish, and no chicken; *Lacto-ovo vegetarian*: milk, pulses, vegetables, fruits or eggs and no chicken and fish; *Lacto-vegetarian*: milk, pulses, vegetables or fruits and no eggs, chicken and fish, and *Vegan*: pulses, vegetables or fruits and no milk, eggs, chicken, and fish. These groups and consumption of *fried food*, *aerated drinks*, *alcohol*, and *tobacco* are binary coded as *one* if any of these items in a group is consumed daily or weekly and *zero* if shown not consuming at all or even occasionally.

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associated with BMI do not have the same effect at the lower tail and upper tail of the BMI distribution.

The quantile regression method (QRM) enables to capture such heterogeneous effect of each covariate (conditional on the remaining covariates), along with different quantiles of the distribution of a continuous variable like BMI (Koenker, 2005; Sharaf *et al*., 2019; and Hossain *et al*., 2021). The QRM is represented as $Y_i = \mathbf{X_i}'\boldsymbol{\beta}_q + u_i$, where for individual i, Y_i represents the outcome variable BMI and $\mathbf{X_i}$ is the vector of covariates. $\boldsymbol{\beta}_q$ is the vector of coefficients for the q^{th} BMI quantile associated with the $\mathbf{X}$ covariates and u_i is the stochastic error term. For every covariate, there will be 'q' estimated coefficients, unlike a single estimate for the OLS regression.

Results

The focus of the first set of discussion is on one covariate, occupation type that captures the nature of manual activity, and how its role changes in managing malnutrition across the BMI quantiles when other covariates are included successively. This is based on a graphical representation of estimates for four occupation types (Table 1) in comparison with not working (NW), who are dominated by young students but could be physically more active. A second set of results discusses interesting insights on other covariates based on coefficient estimates within a quantile. This is followed by a gendered comparison of the role of TV viewing (a covariate available for both men and women) on BMI.

Occupation type, manual activity, and malnutrition

Figure 1a–1d plots the unadjusted estimates (without conditioning on any other covariates) for four categories of occupation types. For the more sedentary occupation, the BMI scores, at the lower quantile, are higher by 1–1.5 kg/m^2 than the NW, increasing to about 2.5 kg/m^2 at the upper quantile (Fig. 1a). For the less sedentary, the positive gaps in BMI scores are similar at the lower BMI quantile but the gap with NW decreases to 2 kg/m^2 at the upper quantile, perhaps due to slightly more physical activity in their jobs (Fig. 1b). For the manual activity jobs, BMI is higher only by about 0.2–0.4 kg/m^2 across the quantiles highlighting far lower values with increased physical activity (Fig. 1c). Lastly, for the other jobs, BMI scores are higher by 0.5–1.5 kg/m^2 from low to high quantiles compared to NW, indicating that such jobs are a mix of manual and sedentary jobs, and whenever the job has a higher physical activity it lowers the BMI and vice-versa compared to the benchmark NW category (Fig. 1d).

Figure 2a–2d shows that after age and squared age are included in the QRM, the age-adjusted estimates for the four occupations are different from the unadjusted estimates. The magnitudes are still positive for sedentary occupations but are statistically different only for lower quantiles compared to NW, implying perhaps that some of the younger population is in less physically intense jobs so that once age is taken into account the positive gap with NW category is only marginal. For manual jobs, there is a pattern reversal with the negative values on the vertical axis of Fig. 2c – the gap with NW across BMI quantiles increases from (−)0.2 to (−)0.85. This is an important finding (that once age is fixed) physical activity from manual occupations lowers BMI among such men but it has larger implications in lowering BMI in the top BMI quantiles. For those with *other* jobs (Fig. 2d), the age-adjusted estimates now range from −0.5 to 0.5 across BMI quantiles compared to NW.

After including the covariate on years of schooling, the grey band overlaps with the dotted confidence intervals for most of the quantiles among the sedentary occupations (Fig. 3a, 3b). Similar to the age variable, education is also strongly associated with occupation type, particularly among the sedentary jobs as a large part of their variation in BMI is explained by age and education and once these two variables are adjusted for, they are no different from NW. In contrast, among the manually active occupations (Fig. 3c), the grey confidence band for QRM

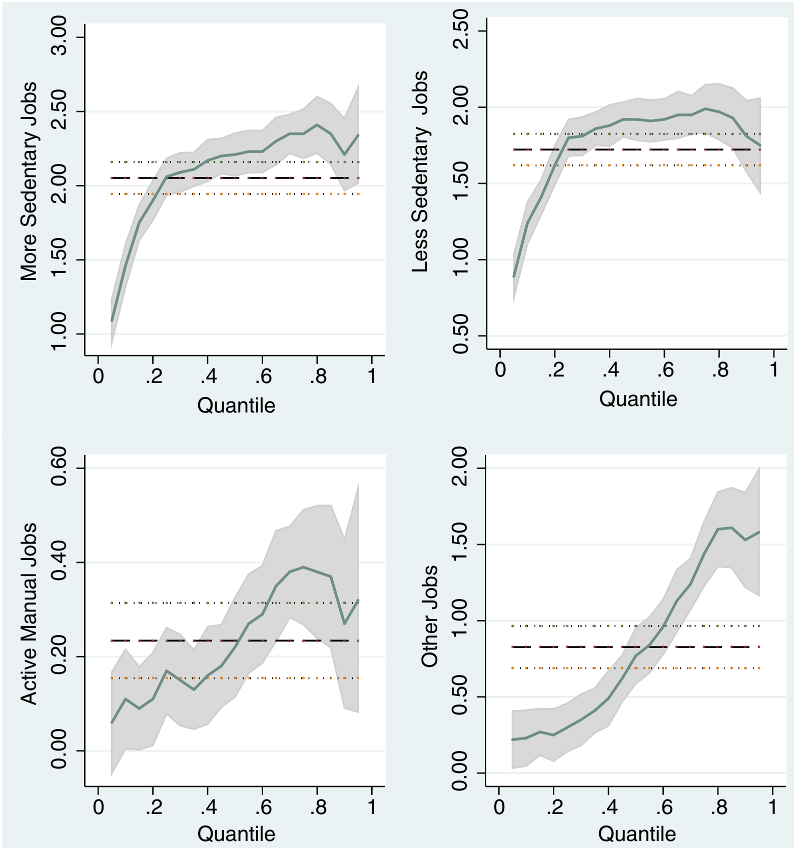

Figure 1. Men's Occupation and BMI Quantile Estimates (unadjusted for other covariates) (a) More sedentary Jobs, (b) Less Sedentary Jobs, (c) Active Manual Jobs, and (d) Other Jobs.

estimates does not overlap with the dotted confidence bands for OLS in the lower and upper BMI quantiles and thus have significant and positive values compared to NW. Further, larger positive values at the lower quantile and negative values at the upper quantiles of BMI show that education in addition to age contributes towards lowering malnourishment for the low and high BMI individuals among manual occupations perhaps due to awareness in managing a good health. Thus, as expected along with age, education is a good marker to discern the variations in BMI between and within job types.

We now present results only for manual jobs that, apart from being the majority, still show variations across BMI quantiles compared to NW after controlling for age and education. Figure 4a plots the estimates adjusted for dietary habits, a set of five dummy variables for the five different dietary habits (with non-vegetarian food habits as the reference), and Fig. 4b adds another covariate on everyday TV viewing, representing sedentary lifestyle habits, compared to those who do not watch TV daily. The physical activity due to such jobs is still relevant in maintaining a better BMI than NW job types. Lastly, after including all the other covariates, there are some marginal changes in the results in manually active jobs compared to NW (Fig. 5c). Up to the 0.6$^{\text{th}}$ BMI quantile, the QRM estimates (straight line) are very close to the OLS estimates (dashed line) indicating that whatever differences between these BMI quantiles are accounted for by those additional covariates. However, for the top 40% of the BMI index, the results show slightly lower estimates compared to NW when the continuous line dips below zero in this figure highlighting the importance of physical activity from manual jobs.

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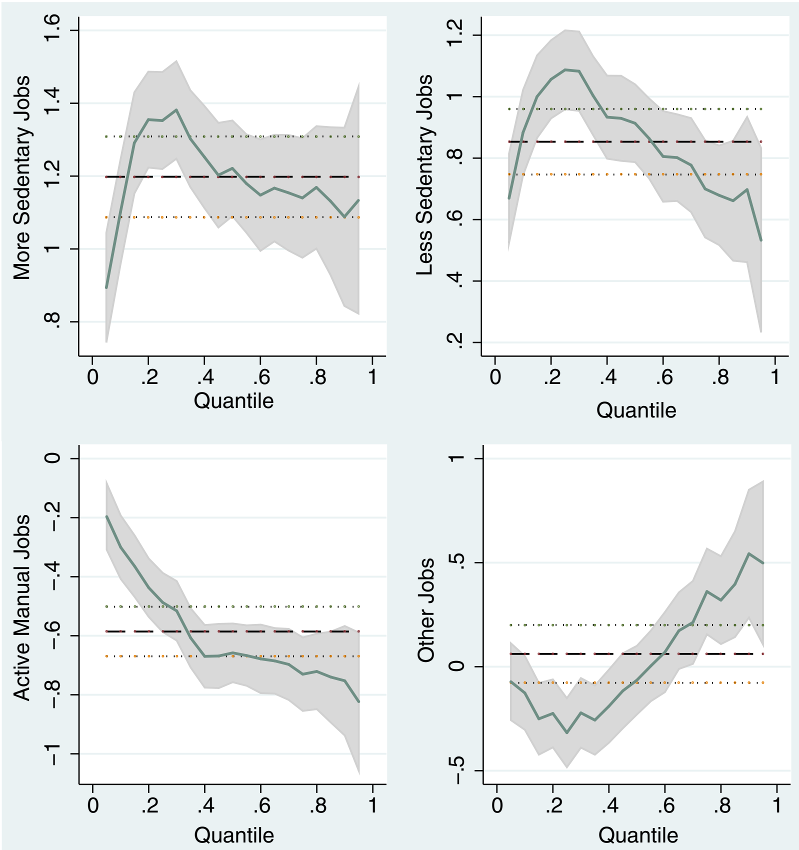

Figure 2. Men's Occupation and BMI Quantile Estimates After Controlling for Age (a) More sedentary Jobs, (b) Less Sedentary Jobs, (c) Active Manual Jobs, and (d) Other Jobs.

Summary of results within BMI quintiles for different covariates

To understand the role of several other covariates, Table 2 shows the regression estimates for each of the covariates included in the model for each of the quantiles: 0.2, 0.4, 0.6, and 0.8. Within every quantile, BMI increases with age and declines at older age, thereby indicating that undernourishment is more prone among the very young and older people, while middle-aged aged are more prone to overweight and obesity. Compared to those without any formal years of education, BMI increases substantially with education within a quantile. However, we observe that the increase in BMI scores is more rapid from 0.15 to 0.85 for 0.2 quantile in comparison to 0.28 to 0.65 in the 0.8 quantile, as education increases from less than 4 years to more than 12 years. Combined with the findings in Fig. 3, this implies that higher education reduces undernutrition but has a limited moderating role to play within the higher BMI quintile.

As for dietary habits, pesco-vegetarian and vegan diets reduce BMI across all quantiles compared to a non-vegetarian diet implying that conditional on low BMI, these diets are not as diversified and hence are associated with underweight. In contrast, conditional on high BMI despite a more diversified non-vegetarian diet compared to all other diets, a large positive coefficient perhaps indicates consumption in excess of the bodily needs and possibly the preparations involving more fatty substances. Under these circumstances, the pesco-vegetarian or vegan diet is more helpful in maintaining a lower BMI. Alcohol consumption does not have significant effect after controlling for other covariates but a negative coefficient for tobacco consumption implies large negative effects on BMI and more so at the higher quintiles. Tobacco

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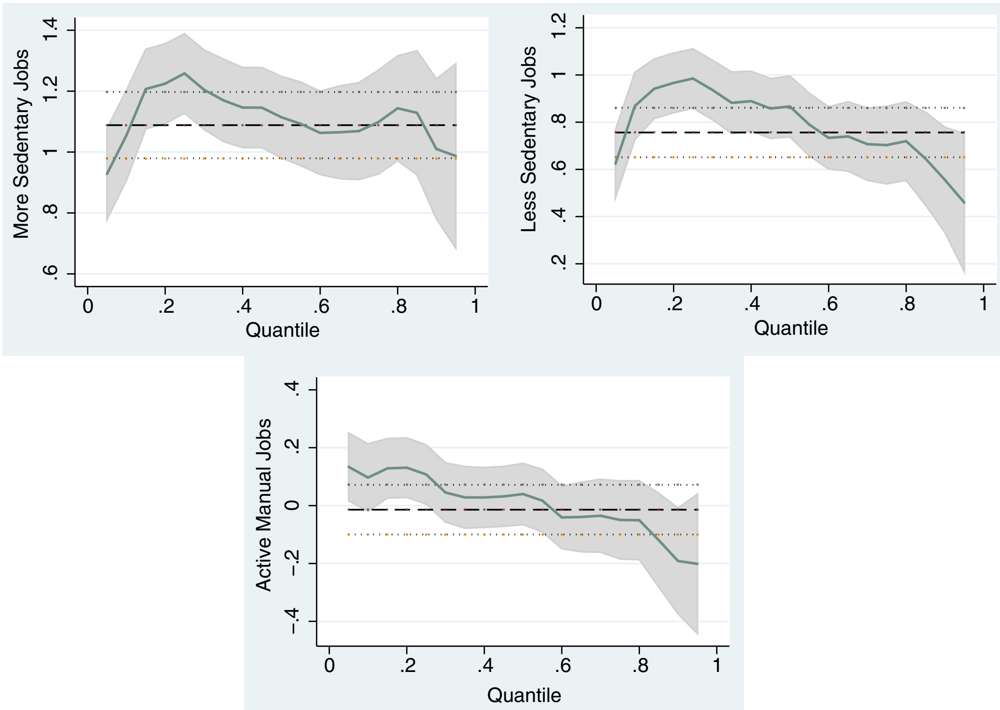

Figure 3. Men's Occupation and BMI Quantile Estimates After Controlling for Age and Education (a) More Sedentary Jobs, (b) Less Sedentary Jobs, and (c) Active Manual Jobs.

consumption to reduce high BMI is perverse, as it will have other adverse health effects. Lifestyle habits of regular TV watching, use of mobile phones, and motorised transport like bike and car (compared to cycling or use of public transport or walking) have large and positive effects on the BMI in upper BMI quintiles after controlling for other economic and social status variables. However, all of these contribute to improving BMI in lower quintiles. A visit to the hospital recently would indicate some illness leading to lowering of BMI on an average for any of the quintiles. Access to health insurance, either from private or employer, reflects a better protection and prevention of health risks and hence a higher average BMI but more so among the top quintiles. This also highlights that treatment for any non-communicable disease at the higher end of BMI may receive quality care when required.

Household characteristics also play an important role in managing individual BMI. Men in households with higher asset quintiles have higher BMI, so economic status improves the BMI for lower quintiles, but a positive coefficient for higher quintiles shows that improved affordability does not lead to either better physical fitness or better quality diets for Indian men. Demographic characteristics like a larger household reduces the BMI while a household with larger share of young children has implications only for the 0.8 quintiles and a higher share of adult females in the household increases the BMI in middle quintiles. All of these are reflective of whether men spend the time in household activities that keep a balance in their BMI either on the lower or higher side. Some religious and caste groups have significant coefficients across all BMI quintiles, indicating that differences in food habits or social status among such groups are not adequately accounted for by the occupation, economic, and lifestyle variables already included in the model.

Even after controlling for several covariates that reflect a region's economic, demographic, and social characteristics, coefficient for urban areas is positive. Several studies observe a geographic concentration of malnutrition of one or both types across Indian states and we reexamine this using QRM by clubbing states into geographic zones (Viswanathan and Agnihotri, 2020).

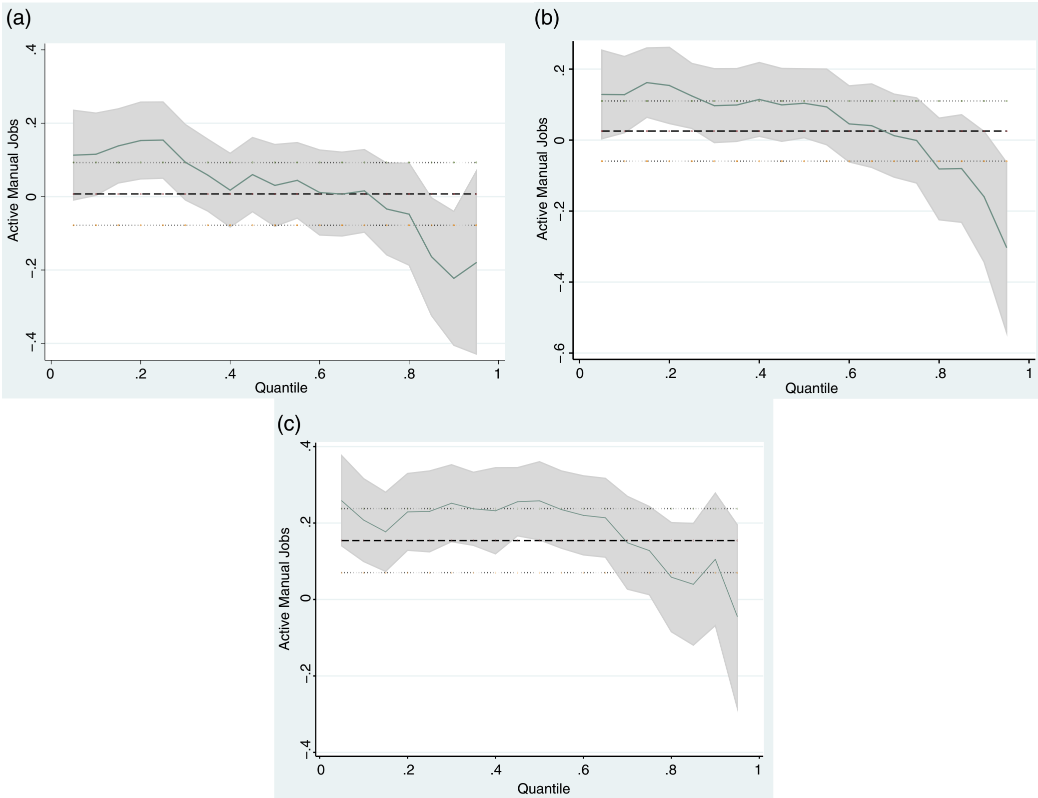

Figure 4. Men's Active Manual Occupation and BMI Quantile Estimates After Controlling for Age, Education, and Three Additional Variables (a) Diets, (b) Everyday TV watching, and (c) All Control Variables.

Compared to Northern India, Central India has a higher burden of undernutrition with negative estimates and larger in magnitude for lower than higher quintiles. Western India reflects a clear presence of double burden of malnutrition wherein the lower quantiles have negative coefficients and the top quintile has a positive coefficient compared to North. Southern India has a concentration of high BMI values across quintiles and the magnitude increases substantially at the upper end compared to North. Eastern India shows a very similar pattern to Northern India but there is higher burden in the upper quintile.

A gendered comparison

In this section, we provide additional robustness checks to understand if the far lower sample size for men gives a different perspective on the association of BMI with its covariates and if this varies across the BMI distribution. Table 1 also shows the summary statistics for men's couple sample. We find that mean BMI and ranking of categories of several covariates and the magnitudes are not very different between the two samples. However, occupation, age, and years of schooling have some dissimilarities and some of the demographic characteristics like marital status, household size, and composition will be different as this is a sample of only married men. These will affect the results at the outset when we consider only the couple sample, but how different would the results be is one direction of enquiry that is pursued here given that sampling weights could adjust for the differences in sample size.

TV watching is the covariate chosen for comparison, which is available for both men and women and is a shared commodity within the household. Figure 5a and 5b shows that compared to those who

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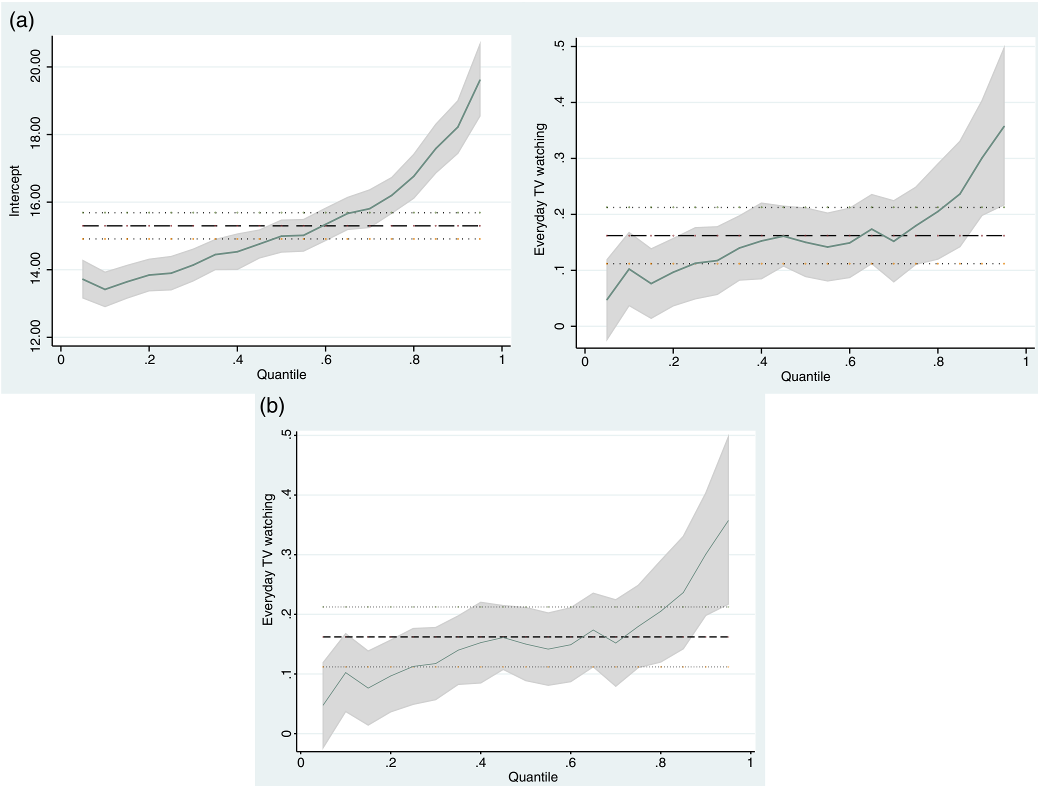

Figure 5. Everyday TV Watching and BMI Quantile Estimates for Men (All Covariates Included) (a) Full Sample and (b) Couple Sample.

do not watch TV daily, the estimates are statistically significant only for the upper quantile in the full and couple samples for men. On the other hand, for women, in Figure 6a and 6b, this coefficient, after controlling for other covariates, shows increasing positive and significant values across the BMI quantiles in the full sample but is not statistically different from the OLS in the couple sample. This finding perhaps shows that a smaller sample may not be as representative of the entire population, and even with the use of sampling weight it seems inadequate to capture the diversity in lifestyle and diets. Similarly, the results for other common covariates in the couple sample are very different (results not shown here) even though the sample size is the same for both groups. This could be due to additional covariates included in the models that are dissimilar for men and women as per their availability in the data set.

Discussion

Unlike the logit, multinomial, or ordinary least squares regression techniques (Ackerson *et al.*, 2008; Young *et al.*, 2020), QRM provides an analytically rich perspective (Dang *et al.*, 2019). The numerical estimates as well as its graphical representation highlight the differences in statistical significance, nature (positive or negative), and the strength (magnitude) of the association of each covariate across the BMI distribution from lower to higher quantiles that is from underweight to overweight and obesity.

Compared to earlier studies on India (Aiyar *et al.*, 2021; Siddiqui and Donato, 2020; Young *et al.*, 2020), the focus here is on men's BMI and the covariates specific to them (job types, alcohol and tobacco consumption, and use of motorised transport) to analyse the double burden of

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Table 2. Quantile Regression Estimates for BMI Among Men Aged 20–54 Years in 2015–2016

	Quantile = 0.2		Quantile = 0.4		Quantile = 0.6		Quantile = 0.8	
Variables	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Occupation: Not working (Base)								
More sedentary jobs	0.81***	0.11	0.56***	0.1	0.54***	0.1	0.32***	0.12
Less sedentary jobs	0.66***	0.1	0.57***	0.09	0.54***	0.1	0.27**	0.13
Active manual jobs	0.30***	0.07	0.17**	0.07	0.18**	0.09	−0.05	0.11
Other jobs	0.25**	0.12	0.31**	0.13	0.35**	0.16	0.65***	0.21
Age	0.27***	0.02	0.30***	0.02	0.31***	0.02	0.36***	0.02
Squared age	−0.003***	0.0003	−0.004***	0.0003	−0.004***	0.0003	−0.004***	0.0003
Education: No schooling (Base)								
1–4 years of education	0.15*	0.08	0.12	0.08	0.19**	0.07	0.28***	0.09
5–7 years of education	0.27***	0.06	0.30***	0.06	0.38***	0.07	0.44***	0.09
8–9 years of education	0.37***	0.06	0.42***	0.06	0.40***	0.07	0.42***	0.09
10–11 years of education	0.67***	0.08	0.71***	0.08	0.64***	0.08	0.62***	0.09
≥12 years of education	0.85***	0.07	0.77***	0.07	0.74***	0.07	0.65***	0.09
Dietary Habits: Non-vegetarian (Base)								
Semi-vegetarian	−0.16*	0.08	−0.04	0.08	0.01	0.07	0.01	0.1
Pesco-vegetarian	0.03	0.07	−0.13*	0.07	−0.19***	0.07	−0.36***	0.09
Lacto-ovo vegetarian	−0.14**	0.07	−0.14*	0.08	−0.1	0.07	−0.1	0.08
Lacto-vegetarian	−0.05	0.06	−0.08	0.06	−0.05	0.06	−0.16**	0.08
Vegan	−0.20***	0.07	−0.30***	0.07	−0.31***	0.07	−0.38***	0.09
Other Consumption Habits								
Fried food	0.03	0.04	0.02	0.04	−0.01	0.04	−0.03	0.05
Aerated drinks	−0.02	0.05	0.07	0.05	0.06	0.05	0.12**	0.06

(*Continued*)

Table 2. (*Continued*)

Variables	Quantile = 0.2 Coefficient	Quantile = 0.2 Std. Err.	Quantile = 0.4 Coefficient	Quantile = 0.4 Std. Err.	Quantile = 0.6 Coefficient	Quantile = 0.6 Std. Err.	Quantile = 0.8 Coefficient	Quantile = 0.8 Std. Err.
Alcohol	0.05	0.05	0.04	0.04	0	0.05	−0.02	0.06
Tobacco	−0.08*	0.04	−0.15***	0.04	−0.16***	0.04	−0.14**	0.06
Lifestyle & Physical Activity								
Everyday television watching (or not)	0.06	0.05	0.16***	0.05	0.11**	0.05	0.24***	0.06
Has Mobile (or not)	0.48***	0.06	0.50***	0.06	0.60***	0.08	0.55***	0.1
Non-motor transport (Base)								
Bike	0.38***	0.05	0.33***	0.05	0.37***	0.05	0.33***	0.06
Car	0.69***	0.1	0.56***	0.11	0.51***	0.1	0.49***	0.15
Household level Covariates								
Marital Status: Never married (Base)								
Currently married	0.45***	0.07	0.44***	0.07	0.49***	0.07	0.51***	0.08
Formerly married	−0.23	0.15	−0.43*	0.22	−0.25*	0.15	−0.33	0.23
Wealth categories: Middle (Base)								
Poorest	−0.43***	0.07	−0.72***	0.07	−0.90***	0.08	−0.99***	0.09
Poorer	−0.26***	0.06	−0.48***	0.06	−0.63***	0.06	−0.59***	0.07
Richer	0.42***	0.07	0.53***	0.07	0.51***	0.07	0.56***	0.09
Richest	1.06***	0.09	1.05***	0.08	0.96***	0.08	0.94***	0.11
Religious Categories: Hindu (Base)								
Muslim	0.35***	0.07	0.34***	0.06	0.31***	0.06	0.27***	0.08
Christian	0.61***	0.13	0.44***	0.11	0.29**	0.14	0.05	0.19
Sikh	0.50***	0.15	0.54***	0.14	0.64***	0.11	0.93***	0.16
Jain	0.25	0.69	0.15	0.44	0.11	0.15	0.14	0.8

(*Continued*)

Table 2. (*Continued*)

Variables	Quantile = 0.2		Quantile = 0.4		Quantile = 0.6		Quantile = 0.8	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Other religions	0.24	0.22	0.21	0.26	0.17	0.19	0.31	0.42
Caste Categories: Don't know caste (Base)								
SC	0.05	0.05	0.00	0.05	−0.04	0.06	−0.07	0.07
ST	0.06	0.06	0.01	0.06	−0.07	0.06	−0.28***	0.08
OBC	0.09	0.06	0.12**	0.05	0.11**	0.05	0.16**	0.07
Other castes	−0.16***	0.05	−0.18***	0.05	−0.22***	0.06	−0.31***	0.07
Visit hospital	−0.31***	0.06	−0.35***	0.07	−0.23***	0.07	−0.23***	0.06
Public insurance (Base)								
No insurance	0.07	0.05	0.06	0.05	0.10*	0.05	0.12**	0.06
Private insurance	0.39*	0.22	0.26	0.25	0.71***	0.12	0.69***	0.22
Employer insurance	0.41*	0.23	0.49***	0.15	0.28	0.21	0.55*	0.31
No of persons in house	−0.03***	0.01	−0.02***	0.01	−0.03***	0.01	−0.01	0.01
Household Composition: Share of adult males (Base)								
Share of young children	−0.39*	0.21	−0.05	0.2	−0.3	0.2	−0.67***	0.25
Share of old children	0.07	0.17	0.34**	0.17	0.45***	0.17	0.23	0.21
Share of teen females	−0.42*	0.23	−0.24	0.22	−0.47**	0.23	−0.82***	0.24
Share of teen males	−0.51**	0.23	−0.07	0.22	−0.19	0.22	−0.3	0.31
Share of adult females	0.08	0.24	0.50**	0.23	0.53**	0.23	0.36	0.27
Share of elder males	0.18	0.31	−0.09	0.41	−0.2	0.36	−0.6	0.5
Share of elder females	−0.17	0.39	0.16	0.38	0.36	0.38	0.73	0.57
Regional Covariates								
Urban (Rural as Base)	0.15***	0.05	0.28***	0.05	0.38***	0.05	0.46***	0.07

(*Continued*)

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Table 2. (*Continued*)

Variables	Quantile = 0.2 Coefficient	Quantile = 0.2 Std. Err.	Quantile = 0.4 Coefficient	Quantile = 0.4 Std. Err.	Quantile = 0.6 Coefficient	Quantile = 0.6 Std. Err.	Quantile = 0.8 Coefficient	Quantile = 0.8 Std. Err.
Geographic Zone: North (Base)								
Central	−0.50***	0.07	−0.53***	0.07	−0.53***	0.06	−0.35***	0.08
West	−0.34***	0.09	−0.19**	0.09	−0.05	0.08	0.42***	0.11
South	0.32***	0.09	0.34***	0.08	0.54***	0.08	0.73***	0.1
East	−0.01	0.08	−0.06	0.08	0.04	0.07	0.17*	0.1
North East	−0.25***	0.09	−0.27***	0.09	−0.1	0.09	−0.11	0.11
Constant	12.60***	0.36	13.44***	0.34	14.68***	0.37	15.80***	0.45

Source: Author's own estimations.
Note: (1) Std. Err-Standard Error;(2)
***, ** and * represent that the estimated coefficients are statistically significant, respectively, at 1%, 5%, and 10% levels of significance.

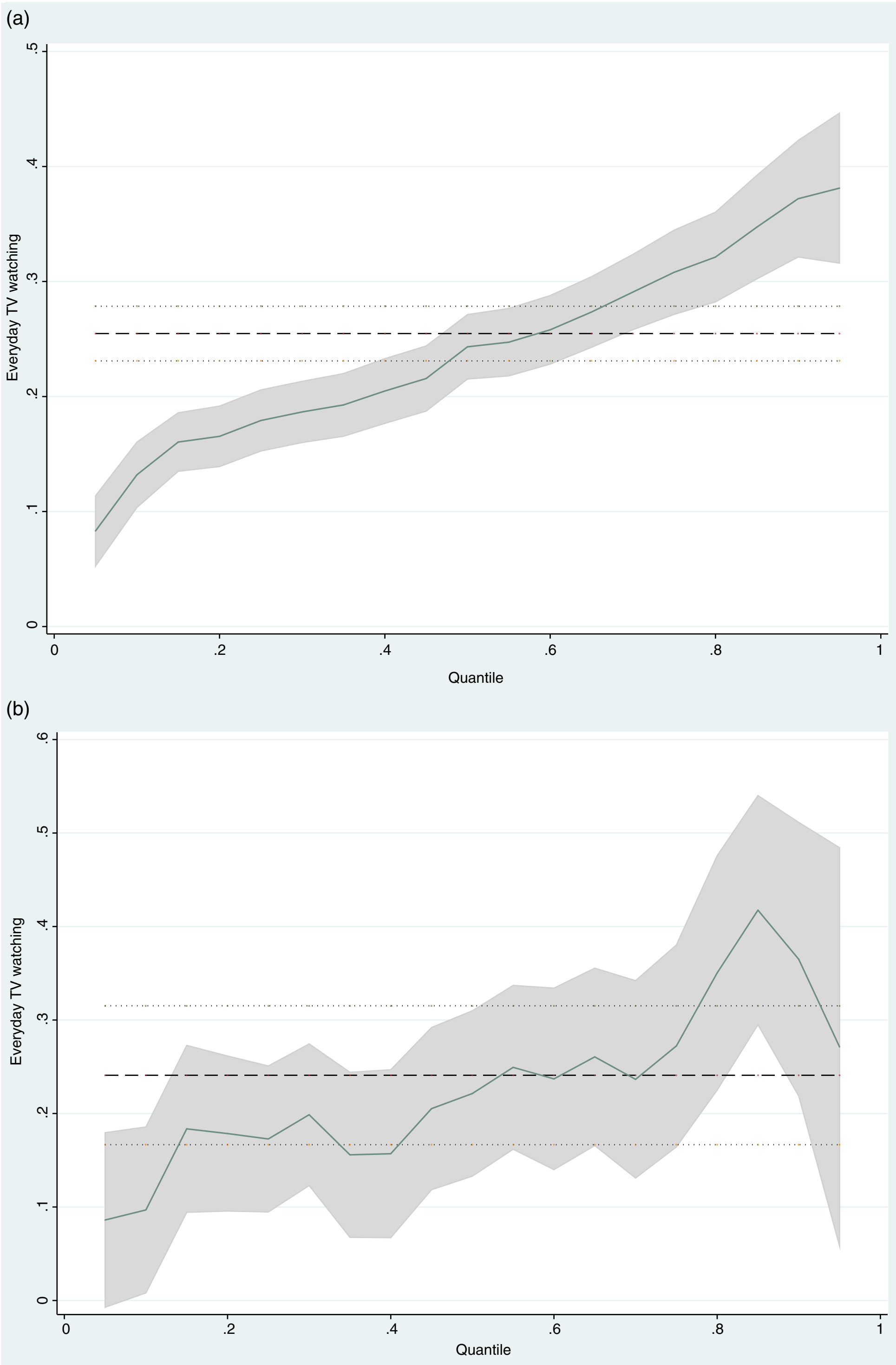

Figure 6. Everyday TV Watching and BMI Quantile Estimates for Women (All Covariates Included) (a) Full Sample and (b) Couple Sample.

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malnutrition. Recent time-use data in India show that men spend substantial time in a day on employment activities (GoI, 2020), implying that men's physical activities and their manual or sedentary nature of jobs are interlinked. Findings from this study that manually active jobs lower BMI – detrimental to those at the lower BMI quantile but beneficial to those at the upper BMI quantiles – are similar to Dang *et al.* (2019) based on a different Indian data set for 2011–2012. The advantage of the data used in this other study is the same sample size and the set of covariates for men and women makes it possible for an appropriate gendered comparison. Their results show that labour market inactivity matters more for women than men in increasing the BMI but do not provide any insights on the double burden of malnutrition even though there was scope to do so.

Low BMI among the young and elderly and a high BMI in middle age concur with findings from earlier studies, a quadratic relation between BMI and age (Som *et al.*, 2014; Dutta *et al.*, 2019). Thus, it is important for age-specific BMI monitoring and management through education and awareness. Higher education's moderating effect on BMI, both at the lower end by improving it and at the higher end by reducing it among adult men, is not observed in studies using other statistical methods; wherein a positive association of education with the probability of overweight/ obesity among men is found (Siddiqui and Donato, 2020). However, studies on women show that overweight and obesity rates increase with education for up to 9 years and then decline for 10 or more years of education (Siddiqui and Donato, 2020; Young *et al.,* 2020).

Adequate quantity and variety in the diets are important to maintain a healthy lifestyle (Dutta *et al.*, 2019; Popkin *et al.*, 2020). Lack of dietary diversity affects both underweight and overweight and hence is a significant factor in reducing the double burden of malnutrition (Nithya and Bhavani, 2018; Young *et al.*, 2020; Aiyar *et al.*, 2021). The policy intervention should improve the access and affordability of such diets. A primary survey of men and women finds animal-based food habits are positively associated with BMI and waist circumference (Satija *et al.*, 2015) while we find no such effect for any of the non-vegetarian diets. Among other food habits, Mathur *et al.*, (2021) show that intake of aerated drinks and fried food are strongly associated with the risk of non-communicable diseases and obesity while we find aerated drinks alone increase BMI at the higher quintile.

In addition to the type of occupations, other lifestyles of low physical activity like more mechanised household activities and a higher use of motorised transport contribute to higher BMI, which is more likely in urban than rural areas (Ramachandran and Kalaivani, 2018). The magnitude of urban coefficient increases across the BMI quintiles and shows the severity of overweight and obesity as an urban problem while undernutrition remains a rural concern (Som *et al.*, 2014). However, in the last decade, villages that are proximate to urban areas have shown an increase in overweight and obesity rates as analysed through more detailed geospatial characteristics by Aiyar *et al.* (2021). India is organised into states and there is an uneven economic development, which then leads to geographic variations, as observed in this study, which appears to have persisted from a decade back (Ackerson *et al.*, 2008). Public health policy has given limited attention to this even though it is easier to address the nature of malnutrition through geographic targeting.

The findings on the gendered differences in the nature of association between the different covariates and BMI call for a separate analysis for men and women based on the NFHS data and further suggest collection of information on all commonly relevant covariates for both genders in future surveys. This would be relevant for health policy planning and in discerning the social constructs of gender differences.

Limitations

A major limitation of this work is the coarse classification of occupation types and a better refinement should be attempted by bringing in inputs from health sciences literature. Very few public policy variables, particularly social safety nets that can influence the BMI directly or indirectly via the covariates, are considered in this study. For instance, Jumrani and Meenakshi (2020) show that in a few states of India where the subsidy on palm oil has improved access to fat intake seems to also have implications on the nutritional status, particularly higher BMI, as palm oil has higher trans-fat content compared to groundnut oil, which is its close substitute. An attempt will be made to incorporate this in future studies.

Conclusions

India is among the most populous and diverse countries in Asia. This results in activities that vary in their nature of manual and sedentary jobs and lifestyles. The double burden of malnutrition is significant among women and men in developing countries and yet more studies examine their causes and consequences for women than for men. This is the first detailed study focusing largely on adult Indian men to provide a detailed discussion on covariates that are associated with double burden of malnutrition based on a rarely used statistical technique of quantile regression model.

The findings are all intuitive that a well-managed lifestyle of physical activity and a diverse diet would keep the BMI in a healthy range. Measurement of BMI involves a non-invasive process to collect data on adult men and women that is also cost-effective and less prone to measurement errors. This not only makes BMI convenient to monitor by the individuals themselves but also easy to record periodically through large-scale surveys for policy planning.

One of the major public health challenges for a developing country is to manage a healthy range of BMI. A poor nutritional status among some young and elderly people could make them more susceptible to infectious diseases and hence poor health. It is important to make affordable access to a variety of fruits and vegetables at all times of the year. This would also improve the pace of recovery from an infectious disease more commonly observed among the undernourished. The access to primary health care for the poorer sections is equally important. Similarly, awareness about diabetes and hypertension and their implications for prolonged ill health for the middle and upper-income sections of the population with access to medical insurance and affordable hospital care for timely intervention are the key aspects to focus on for public health policy.

Data availability statement. Data and other factsheets of NFHS are available free of charge to researchers at Demographic and Health Surveys website. For details, visit https://dhsprogram.com/data/available-datasets.cfm

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