Obesity and its Impact on COVID Occurrence: Evidence from India

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Abstract

Over-nutrition has emerged as a major public health issue in India. Being overweight or obese has been linked to non-communicable diseases (NCDs) which are also linked to susceptibility and severe illness due to COVID. This paper investigates the association between over-nutrition indicators and COVID prevalence and case fatality rate, for India. Using nationally representative dataset National Family Health Survey – 4 and COVID data, estimates show that over-nutrition is significantly associated with NCDs and, therefore, over-nutrition indicators are utilized as a surrogate for NCDs. State and district-level analysis indicate strong and significant relationships between over-nutrition and COVID prevalence and fatality rate. Results underscore the importance of addressing obesity in general for successful NCDs prevention strategies, targeting messages of COVID prevention among obese individuals as well as the development of additional vaccination strategies for COVID that take into account the link between COVID and obesity.

Keywords: COVID, overweight or obesity.

JEL: I120

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1 Introduction

India is rapidly undergoing a nutrition transition, with significant undernutrition among adults and children coexisting with high magnitudes of overweight and obesity. The extent of undernutrition in India is about 20% among adults (National Family Health Survey-4, National Fact Sheet, 2016) and is now well-documented. However, overweight and obesity rates exceed one-third in several parts (National Family Health Survey-4, State Fact Sheet, 2016) of India, and yet, this phenomenon has not received as much attention in the literature.

Evidence emerging from multiple countries have suggested that among adults aged less than 65 years (generally considered a lower-risk group of COVID disease severity), obesity appears to be an independent risk factor for hospital admissions, need for critical care and mortality due to COVID (Lighter et al., 2020; Simonnet et al., 2020; Zheng et al., 2020; Caussy et al., 2020; Muniyappa and Wilkins, 2020). People with high BMI are more likely to have metabolic disorders (such as abnormal blood glucose, high cholesterol HDL, and blood pressure) which then progress to a variety of diseases including type 2 diabetes, cancers, and cardiovascular diseases, increased risk of respiratory infections and inflammatory lung diseases (Salvator et al., 2020). Metabolic dysregulation due to excess body fat can impair the immune system to increase the risk of infections and respiratory diseases (Poulain et al., 2006).

A meta-analysis of the association between obesity and COVID from pooled data from about 20 studies show that the odds of individuals with obesity being COVID positive were 46.0% higher than those of individuals who were not obese (Popkin et al., 2020). Furthermore, the odds of individual being obese increases hospitalization by 113%, ICU admission by 74% and mortality risks by 48% respectively. Excess body weight reduces the lung's capacity and since the COVID virus mainly affects the lungs, this may significantly increase the risk of mortality in COVID patients (Simonnet et al., 2020).

So far, India has reported more than 12 million confirmed COVID cases, the third-highest in the world after the US and Brazil. The situation improved substantially since September 2020, when about 90,000 cases were being reported each day. The reported daily cases had come down to between 12,000-15,000, though there is again a spike in cases since the beginning of March 2021 and India is currently experiencing a second wave.

A large number of studies have documented the risk of severe illness and fatality from COVID being significantly associated with increasing age (more than 75% of the deaths have been in patients aged 65 years or above), and also with certain underlying medical conditions such as diabetes, serious heart conditions, hypertension, chronic kidney disease etc (see, for example, Zhang et al. 2020; Wu and McGoogan 2020; Holman 2020; CDC 2020). Many of these health conditions are associated with or caused by excess body weight/fat (Singh et al., 2013; Pi-Sunyer, 2009).

Overweight/obesity has emerged as a major public health issue in India and states like Kerala, Tamil Nadu and Punjab the prevalence is even comparable to rates in developed countries. World Health Organisation (WHO) and Centers for Disease Control and Prevention (CDC) have included overweight/obesity as one of the risk factors for severe and life-threatening COVID infections. Also, vaccines for influenza, tetanus, hepatitis A and B and rabies are less effective in individuals who have excess weight or obesity (Karlsson et al., 2019; Neidich et al., 2017; Eliakim et al., 2006; Miñana et al., 1996; Weber et al., 1985), raising the possibility of reduced COVID-vaccine efficacy among over-nourished individuals (Pellini et al., 2021).

Literature from past pandemics highlight obesity negatively impacting immunity; for example, individuals with obesity was identified as an independent risk factor for severe influenza morbidity and mortality in the 2009 H1N1 influenza pandemic (Louie et al., 2011). In 2012, the Middle East respiratory syndrome coronavirus (MERS-CoV) exhibited a high prevalence among individuals with obesity (Badawi and Ryoo, 2016). The evidence from past pandemics would help understand the exact mechanism between overweight/obesity and COVID (a new respiratory disease) prevalence and severity, and research on this is ongoing (O'Rourke and Lumeng, 2020).

Menon (2021) investigates the correlation between BMI and early spatial distribution and intensity of COVID across districts of India. Conditioning on range of individual, household and regional level variables, Menon (2021) finds that BMI is significantly associated with intensity of covid prevalence; the result remains stable across different sensitivity checks. However, Menon (2021) finds insignificant relationship between BMI and COVID case fatality rate.

The present study uses recent COVID data and examines the relationship of excess body weight (using overweight and obesity as an indicator) with COVID prevalence and COVID case fatality rate (CFR) respectively, for India. The analysis is done both at the state as well as district levels using the nationally representative data from the National Family Health Survey (NFHS-4) conducted in 2015-16, in conjunction with data on COVID available from reliable sources. Using more current data, the study contributes to the literature by not just providing evidence on the significant association between overnutrition and COVID prevalence but also provides strong evidence on the significant relationship between overnutrition and COVID fatality rate. Additionally, the study is able to bring out the differences between using obesity as compared to using indicator of being overweight and their relation with COVID prevalence and CFR, yielding additional policy insights.

2. Over-nutrition in India

Studies on India suggest that average calorie intakes have not increased over time but have seen a modest decline (Deaton and Drèze, 2009; Ramachandran, 2014; Meenakshi, 2016). Calories reported in these studies are likely to be underestimated as there are concerns whether the National Sample Survey Organization (NSSO) – which is the basis of these various research - captures processed food or meals eaten outside adequately. Since eating out has significantly increased over time (Ghosh and Qadeer, 2017), the underestimation is likely to increase (Meenakshi, 2016). Despite these concerns, researchers have documented increased consumption of sugar, oils and highly processed food in Indian diets (Popkin et al., 2001; Shetty, 2013; Sharma et al., 2020). Meenakshi (2016) reports increase in calories from oils and sugars, and also an increase in the overall fat intake from 31 grams per capita per day (pcpd) in 1993-94 to 42 grams pcpd in 2011-12 in rural India, while the corresponding increase in urban India was from 42 to 53 grams pcpd. Furthermore, Law et al. (2019) found that the per capita annual purchase of sweet and salty snacks in India rose by 17% and 9% respectively, from 2013 to 2017. Purchases of edible oils and other processed foods (such as ready to cook, ready to eat, ketchup etc.) also showed an increasing trend.

Yet other studies attribute decline in energy intake to decreased physical activity levels and improved living conditions (Deaton and Drèze, 2009; Ramachandran, 2014). It has been argued (Ramachandran, 2014) that the decline in activity levels has been more rapid in urban areas which have contributed to increased over-nutrition levels. Dang et al. (2019 a), for urban India, provide evidence for decreased activity levels at work as a contributing factor for increased BMI levels. Furthermore, Dang et al. (2019 b) find a positive association between labour-saving devices and overweight and obesity levels across states in urban areas. The evidence on mechanization is not limited to urban areas; Eli and Li (2015) document a decrease in activity levels in rural areas as well.

Earlier studies found women being more susceptible to over-nutrition as compared to men (see for example Ramachandran, 2014; Kulkarni et al., 2014; Subramanian et al., 2009; Chhabra and Chhabra, 2007), but Siddiqui and Donato (2020) observe that the gap has narrowed considerably reflecting a convergence between the genders. Earlier literature on over-nutrition in India suggests that socio-economic status represented by wealth/income and education levels are strong predictors of over-nutrition, and the probability of being overweight/obese for the highest wealth quintile is greater than for the lowest one. This is in contrast to what is observed in developed countries (where concentration is higher among the poor), though more recent studies indicate that this difference has narrowed (Siddiqui and Donato, 2020; Vishwanathan and Agnihotri, 2020). Siddiqui and Donato (2020) - for some states (like Kerala, Punjab, Haryana) - find overweight/obesity to be lower for the highest wealth quintile in 2015–16 than in 2005–06, which suggests that obesity transition is beginning to emerge in these states. Moreover, overweight and obesity are no longer an urban phenomenon; Siddiqui and Donato (2020) find a steeper (and positive) wealth gradient for rural (compared to urban) population for the year 2015-16 as compared to 2005-06 and, therefore, indicate convergence between urban and rural sectors.

Similarly, the earlier findings of a positive relationship between education and being overweight among women (Kulkarni et al., 2014; Griffiths and Bentley, 2001) are now being replaced with findings from recent studies (see, for example, Siddiqui and Donato, 2020) that find that in case of females, beyond a threshold of 7-9 years of education, a negative relationship develops, and this inverted U-shaped relationship is not observed for male cohorts.

3. Data and variable construction

Three main variables are used in the analysis: (a) over-nutrition indicators as proxies for NCDs, (b) COVID prevalence rates and (c) COVID case fatality rates (CFR). The analysis is done first at the state-level, and then at the district-level.

This study uses the fourth round of the National Family Household Survey (NFHS-4), a nationally representative survey conducted in 2015-16. The survey collected information on population, health and nutrition for India and each State/Union territory. For the first time, NFHS-4 provides district-level estimates for many important indicators. The survey collected data for height, weight, blood pressure, and random blood glucose for women aged 15-49 years and men in the age group of 15-54 years. These variables are utilized to construct over-nutrition indicators and health outcome variables such as diabetes and high BP. The study also uses NFHS-3 conducted in 2005-06 (in Section 4) to show how the prevalence of over-nutrition has changed over time.

Body mass index (BMI) defined as the ratio of weight (in kilograms) to height (in meters) squared is used to categorize individuals into different weight categories: underweight (BMI < 18.5), normal weight (BMI $\in [18.5, 25)$), overweight (BMI $\in [25, 30)$), obese (BMI $\in [30\ and\ above)$). Using these cut-offs, prevalence rates of overweight (proportion of men and women with BMI≥25) and obesity (proportion of men and women with BMI≥30) are obtained.[3] An individual is classified as being diabetic if the random blood sugar level is greater than 140 mg/dl. If an adult's systolic reading is above 140 mm of Hg and/or diastolic is above 90 mm Hg, that individual is categorised as having high BP issues. Individual-level data is used for both men and women in Section 5 and in Section 6 state/district-level estimates are used for the analysis.

Data on COVID for India at the state and district-level (till 24th December 2020) is obtained from https://api.covid19india.org/. This website compiles data on COVID from trusted (government) sources. States/districts in NFHS-4 are matched with the states/districts given in the COVID data. State/district-level COVID prevalence rate is calculated as the ratio of total COVID confirmed cases to total samples tested(multiplied by 100), and case fatality rate (CFR) as the total number of confirmed deaths due to COVID to the total number of confirmed cases of COVID(multiplied by 100).

4. Prevalence of COVID and over-nutrition in India

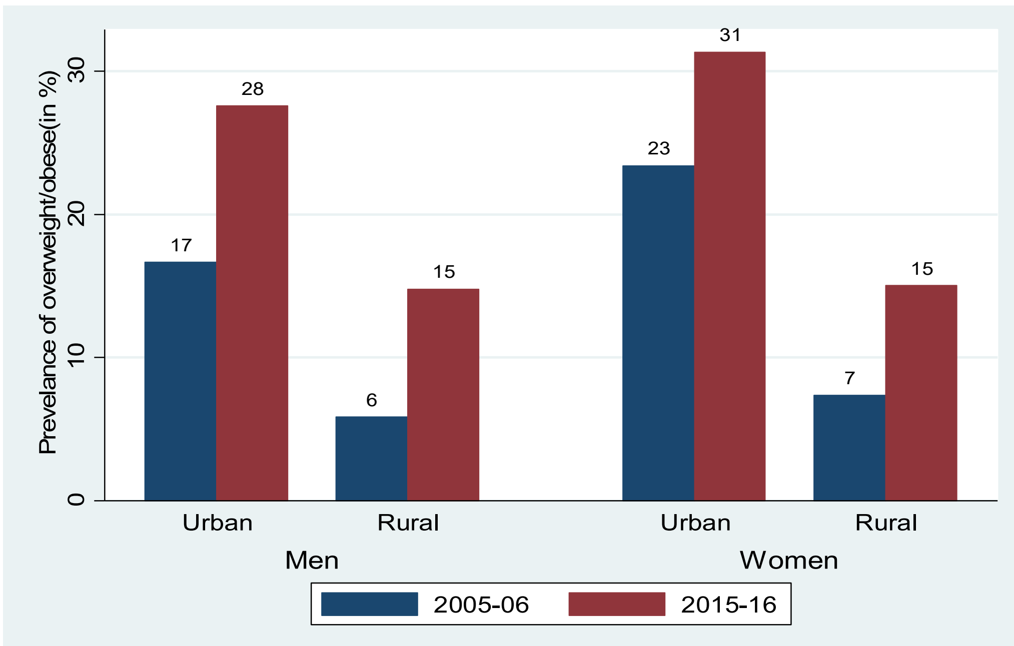
4.1 Distribution of Overweight/Obesity in India

Using the standard benchmark to categorise adults in weight categories, Figure 1 below indicates that overweight and obesity prevalence is higher in urban areas, as expected. The proportion of overweight/obese men increased by 11 percentage points from 2005-06 to 2015-16, while among women it increased by 8 percentage points. Figure 1 indicates that though the proportion of overweight/obese women is higher, the prevalence increased sharply for men in a decade.

[3] Women who were pregnant are excluded at the time of survey while calculating overweight and obesity prevalence rates.

In rural areas, the proportion almost doubled for both men and women, from 6% in 2005-06 to 15% in 2015-16; the corresponding figures for women are 7 % and 15%. The prevalence of obesity is higher among urban women - 9% as compared to 5% among urban men in 2015-16 (Figure A1 in appendix). In rural areas, the proportion is 3% and 2% among women and men respectively (see Figure A1 in appendix).

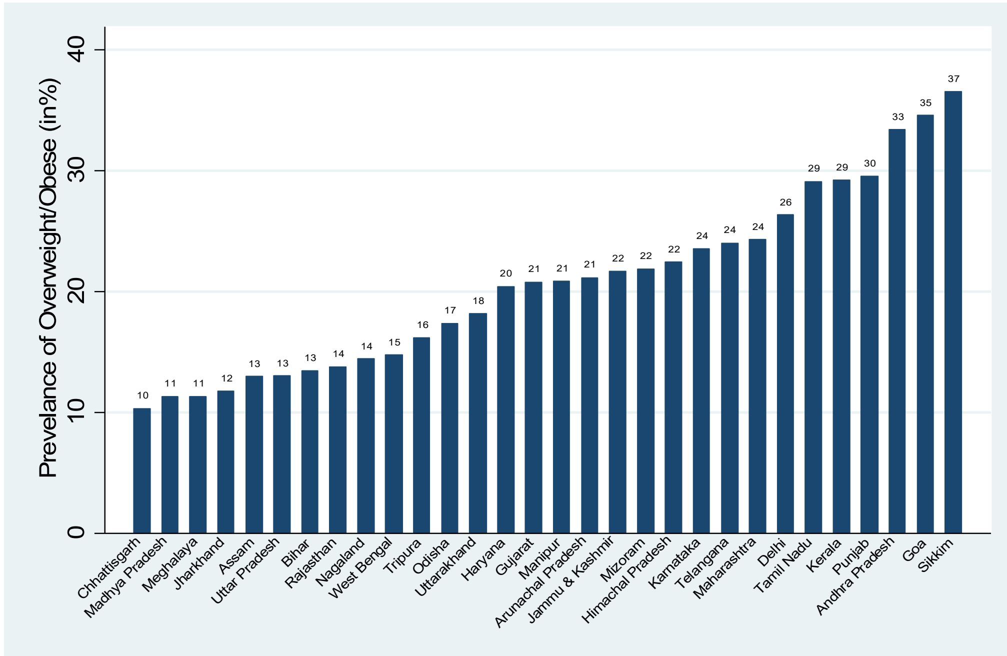
Figure 1: Prevalence of Overweight/Obese, by Type of Residence and Gender (in %)



Notes: Data refer to men aged 15 to 54 years and women aged 15-49 years. An adult is classified as overweight/obese if his/her BMI is ≥25 kilograms per meters squared.
Sources: 2005-06 and 2015–2016 data are computed from the unit record data of the third and fourth rounds of the National Family Health Survey.

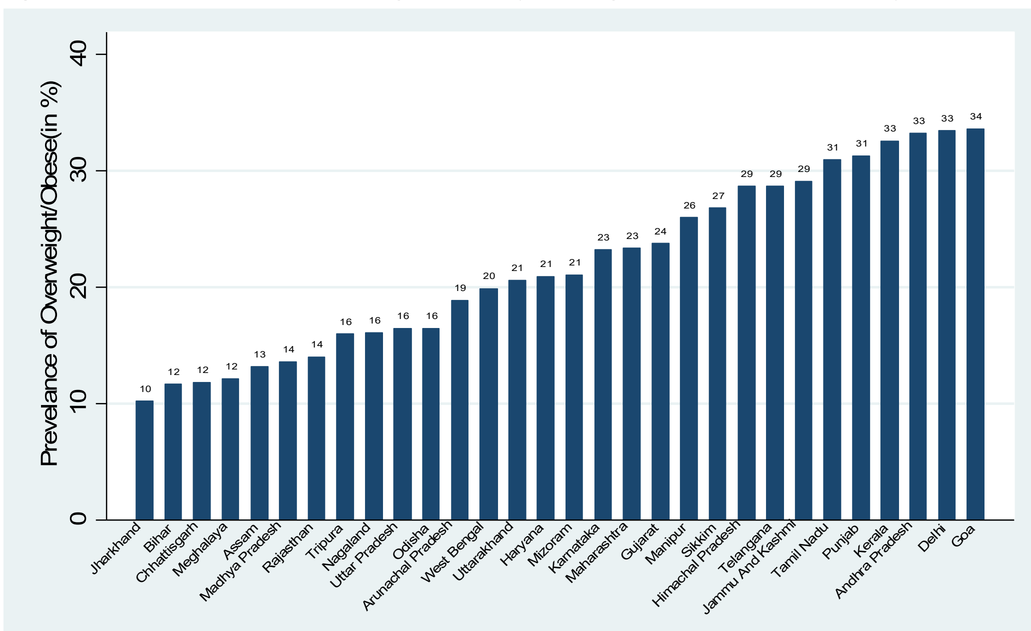
Figure 2 below shows the prevalence of overweight/obesity across states in 2015-16 among men. The top 10 states with the highest proportion of overweight/obese men include large states like Kerala, Punjab, Tamil Nadu, Andhra Pradesh and Maharashtra, small states and union territory (UT) such as Delhi, Goa and Sikkim. The prevalence is above 20% in all these states; in larger states like Punjab, Kerala and Andhra Pradesh the figure is close to or above 30%. States like Chhattisgarh, Madhya Pradesh, Meghalaya, Jharkhand have the lowest prevalence. Obesity prevalence is the highest in Andhra Pradesh and Goa (8%) followed by Punjab and Sikkim (6%), while the prevalence rate in Tamil Nadu, Kerala and Delhi is 4% (see Figure A2 in appendix).

Figure 2: Prevalence of Overweight/Obesity among Men in 2015-16, by State(in %)



Notes: Data refer to men aged 15 to 54 years. An adult is classified as overweight/obese if his BMI is ≥25 kilograms per meters squared.
Sources: Data is computed from the unit record data of the fourth round of the National Family Health Survey conducted in 2015-16.

Figure 3: Prevalence of Overweight/Obesity among Women in 2015-16, by State(in %)



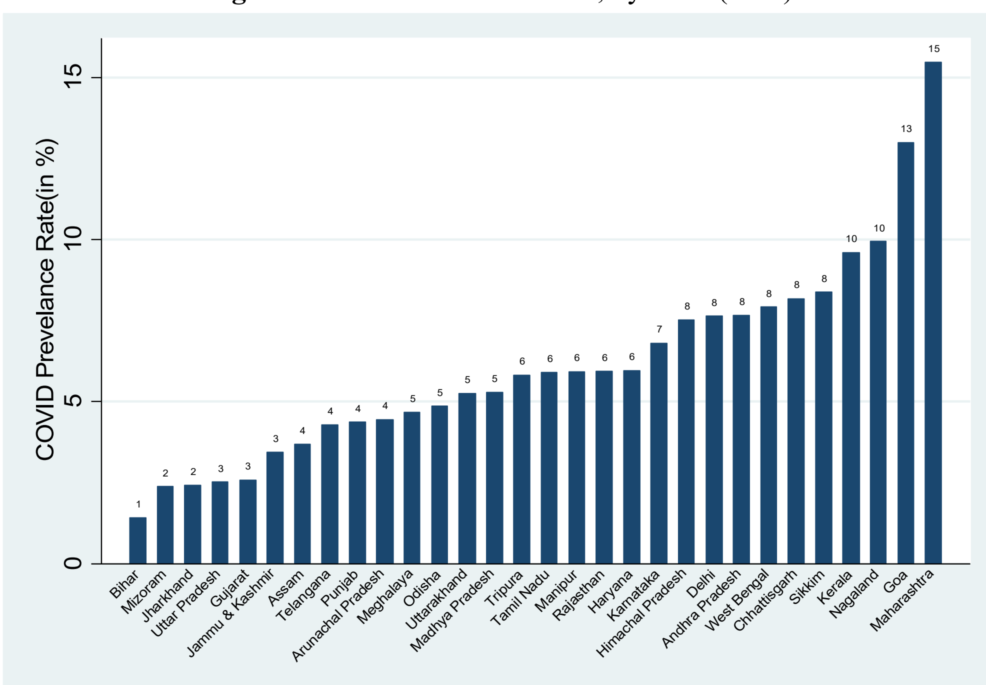
Notes: Data refer to women aged 15 to 49 years. An adult is classified as obese if her BMI is ≥25 kilograms per meters squared.
Source: Data is computed from the unit record data of the fourth round of the National Family Health Survey conducted in 2015-16.

A similar pattern is observed for females as well. States such as Andhra Pradesh, Tamil Nadu, Kerala, Punjab, Goa and UT like Delhi (prevalence is above 30%) have the highest prevalence while Jharkhand, Bihar, Chhattisgarh have the lowest prevalence (below 15%). Andhra Pradesh, Delhi and Goa are on the top with a 10% prevalence rate of obesity. The prevalence of obesity in Tamil Nadu, Punjab, Kerala, Karnataka is between 6% - 9%.

4.2 Distribution of COVID-19 infections and case fatality rate (CFR).

Figures 4 and 5 below show COVID prevalence and CFR across states. Figure 4 reveals that till 24th December 2020, the COVID prevalence (or positivity rate) was the highest in Maharashtra (15%) followed by Goa (13%) and Kerala (10%). Tamil Nadu, Andhra Pradesh, Delhi are among the top 6 states with a 6% and 8% positivity rate, respectively. Bihar, followed by Jharkhand and Mizoram have the lowest prevalence rate.

Figure 4: Prevalence of COVID, by State (in %)

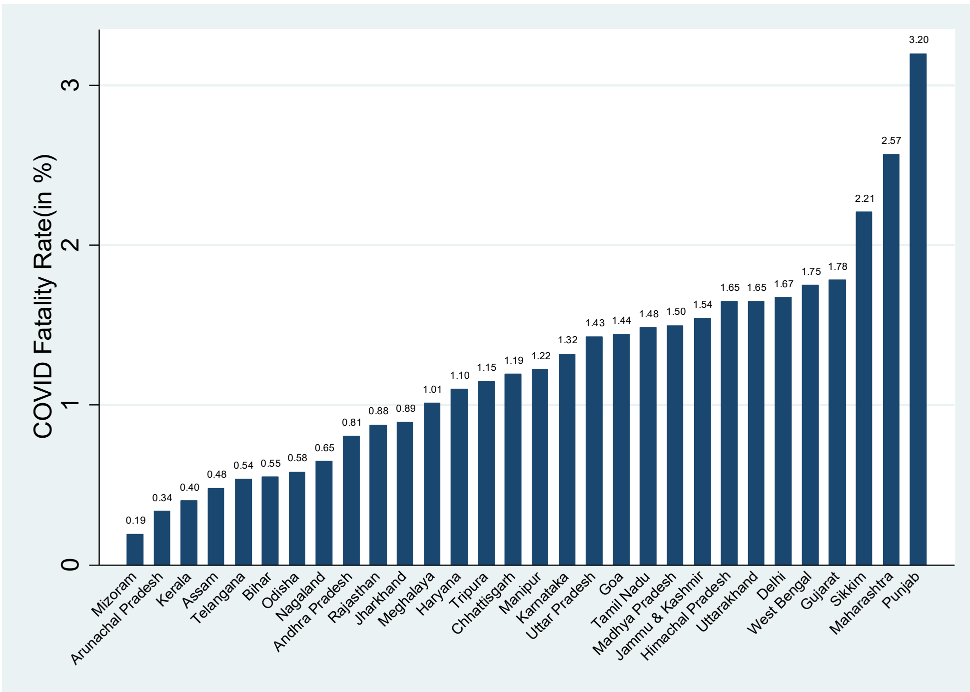


Notes: (Total confirmed COVID cases in a state/Total samples tested in a state)*100.
Source: COVID estimates are computed using data obtained from government sources.

While overall CFR for India is low (Figure 5), variations across states are observed. Punjab with 3% has the highest CFR of COVID-19, followed by Maharashtra, Sikkim, Gujrat, West Bengal, and Delhi. Tamil Nadu with CFR 1% is also among the top 10 states. From Figures 2-

5, one can see that states like Punjab, Tamil Nadu, Delhi, Kerala and Andhra Pradesh fall in the upper distribution of over-nutrition and COVID-19 indicators, suggesting a possible positive correlation between the two. To verify this statistically, regressions are estimated, reported in the next section.

Figure 5: Case Fatality Rate (CFR) of COVID, by State (in %)



Notes: case fatality rate = (Total deaths due to covid in a state/Total confirmed covid cases in a state)*100.
Source: COVID estimates are computed using data obtained from government sources.

5. Impact of over-nutrition on health outcomes

The prevalence of overweight and obesity, in turn, impacts health as is well documented globally. Excess body weight is one of the major causes of several diseases worldwide, constituting an important risk factor for, type 2 diabetes, hypertension, cardiovascular diseases (CVDs) and many forms of cancer (Messerli, 1982; Mokdad et al., 2003; Singh et al., 2013). Therefore, this study investigates the correlation of being overweight or obese on the probability of having non-communicable diseases such as diabetes and high BP in India, by estimating a logit regression which takes the following form:

$$D_i = \delta_0 + \delta_1 Underweight_i + \delta_2 Overweight_i + \delta_3 Obese_i + \delta_4 \boldsymbol{X_i} + \mu_i \qquad (1)$$

D_i is the health outcome of individual i and, $\boldsymbol{X_i}$ is a vector of individual-level controls such as age and sex. Three specifications are estimated: (i) D_i takes value 1 if an individual is diabetic and 0 otherwise, (ii) D_i takes value 1 if an individual has high BP and 0 otherwise, and (iii) D_i takes value 1 if an individual is diabetic and/or has high BP and 0 otherwise. BMI categories such as underweight, overweight and obese relative to being normal weight are utilized as variables of interest. The NFHS data is used to estimate the regressions.

Table 1 below presents the average marginal effects of being overweight/obese/underweight on the probability of being diabetic or having high BP or both. Column (1) presents the results using being diabetic as the dependent variable and shows that obese adults (i.e., women aged 15 to 49 years and men aged 15 to 54 years) vis-a-vis normal-weight adults are 8.5% more likely to have diabetes, while, overweight adults have 3.7% higher chances of being diabetic as compared to normal-weight adults. Results reported in Column 2 show that individuals who are overweight and obese relative to normal-weight individuals are 12% and 19.4% more likely of having high BP issues respectively. Similarly, adults having both or either of the health issues is more likely to be overweight or obese compared to normal-weight adults. Moreover, estimates suggest that the magnitude of the coefficients in Table 1 indicate that obese individuals as compared to overweight adults have a higher probability of being diabetic or having high BP or both. Underweight individuals are significantly less likely to have these health issues relative to normal-weight individuals. Lastly, the results below indicate that men vis-a-vis women and older adults are more likely to have NCDs.

Being overweight/obese could be endogenous due to unobserved factors such as heredity affecting both BMI and diabetes/high BP. Also, there could be simultaneity between BMI and being diabetic, and, therefore, recognize that these results represent correlations and are not causal. But these results seem to suggest that being overweight/obese plays a significant role in predicting the incidence of NCDs such as diabetes and high BP as documented in other studies as well.

Table 1: Average Marginal effects of BMI categories on Diabetes/High BP status: Logit Estimates

Dependent variable is a binary variable	Dependent variable=1 if individual is diabetic	Dependent variable=1 if individual has high BP	Dependent variable=1 if individual is diabetic or has high BP or both
Underweight (relative to normal weight)	-0.004*** (0.001)	-0.030*** (0.001)	-0.029*** (0.001)
Overweight (relative to normal weight)	0.037*** (0.001)	0.073*** (0.001)	0.096*** (0.001)
Obese (relative to normal weight)	0.085*** (0.002)	0.121*** (0.002)	0.176*** (0.003)
Female (relative to male)	-0.016*** (0.001)	-0.043*** (0.001)	-0.054*** (0.001)
Age in years	0.003*** (0.000)	0.006*** (0.000)	0.008*** (0.000)
Observations	758,521	733,568	732,067

Notes: Data refer to men aged 19 to 54 years and women aged 15 to 49 years. Individual is diabetic if random blood sugar level is > 140 mg/dl and has high BP if systolic reading > 140 mm of Hg and/or diastolic > 90 mm Hg. Individual is defined as underweight when BMI <18.5 kg/m^2; overweight when BMI ≥25 kg/m^2 and obese when BMI ≥30 kg/m^2. Standard errors in parenthesis. Significance: * p < 0.10, ** p < 0.05, *** p <0.01.
Source: Based on unit record data of the fourth round of National Family Health Survey conducted in 2015-16.

6. Evidence on the correlation between over-nutrition and COVID

6.1 State-level Analysis

Since being overweight and obese are significant predictors of diabetes and BP, these indicators can be used as a marker for NCDs in the equation for COVID prevalence. Looking first at state-level analysis where a bivariate regression of the following form is estimated.

$$Covid\ prev_s = \theta_0 + \theta_1 Over - nutrion\ indicators_s + \tau_i \qquad (2)$$

and

$$Covid\ CFR_s = \beta_0 + \beta_1 Over - nutrion\ indicators_s + \epsilon_i \qquad (3)$$

$Covid\ prev_s$ is the prevalence rate of COVID in state s and our variable of interest is $Over - nutrion\ indicators_s$, which is the prevalence rate of over-nutrition in the state s. Two indicators are utilised for over-nutrition, a) proportion of individual who are overweight

(BMI ≥25 Kg/m^2) and b) proportion of individual who are obese (BMI ≥ 30 Kg/m^2). In equation (3), $Covid\ CFR_s$ is the case fatality rate (CFR) of COVID in state s.

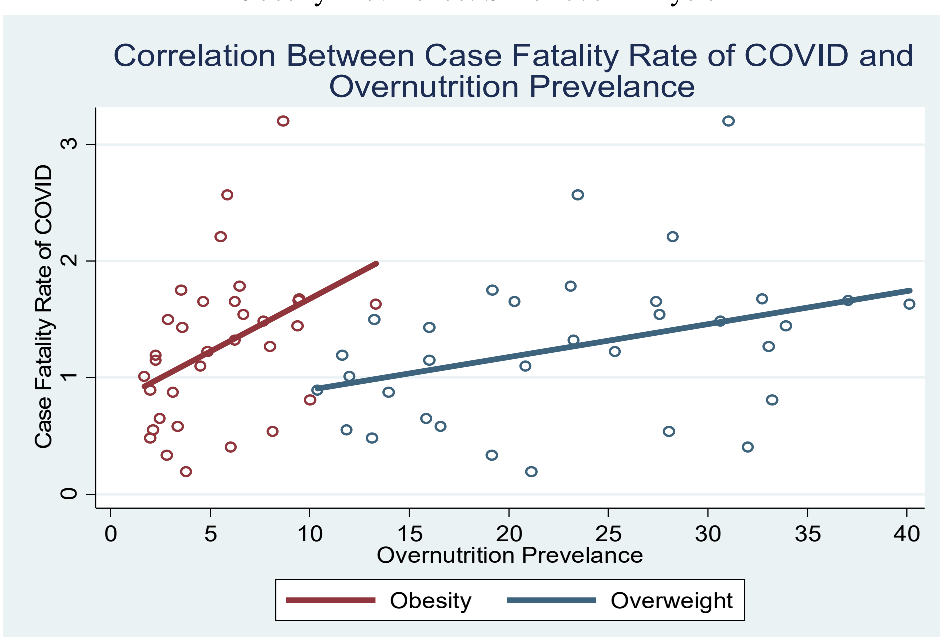
Table 2 below shows the regression results of equation (2). Results show that the correlation between over-nutrition and COVID prevalence is positive and significant. Moreover, using obesity as an indicator of over-nutrition, the relationship becomes stronger.

Table 2: Regression of prevalence of COVID on Prevalence of Overweight and Obesity: State-level Estimates

Over-nutrition Indicators	**Dependent variable is prevalence rate of COVID**	**Dependent variable is prevalence rate of COVID**
Prevalence of Overweight	0.153** (0.062)	------
Prevalence of Obesity	-----	0.413** (0.179)
Observations	33	33

Note: Individual is defined as overweight when BMI ≥25 kg/m^2 and obese when BMI ≥30 kg/m^2. Standard errors in parenthesis. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Based on unit record data of the fourth round of National Family Health Survey conducted in 2015-16 and COVID data is obtained from government sources.

Figure 6: Association between Case Fatality Rate (CFR) of COVID and Overweight and Obesity Prevalence: State-level analysis



Note: Individual is defined as overweight when BMI ≥25 kg/m^2 and obese when BMI ≥30 kg/m^2.
Source: Based on unit record data of the fourth round of National Family Health Survey conducted in 2015-16 and COVID data is obtained from government sources.

Figure 6 shows the predicted values of regression described in equation (3) above using overweight and obesity as surrogate indicators of NCDs. Estimates suggest a significant and positive relationship between COVID CFR and overweight and obesity prevalence. The figure above shows that the regression line is steeper i.e., the association between CFR and the stronger definition of over-nutrition - obesity – is stronger.

6.2 District-level Analysis

Regressions using data at the state-level may be problematic because of variations of COVID prevalence across districts within a state. Since district-level information is available, it makes logical sense to do district-level analysis. Essentially, this means that using equations (2) and (3) on district-level data instead of state-level data.

$$Covid\ prev_d = \alpha_0 + \alpha_1 Overnutrion\ indicators_d + \tau_i \qquad (4)$$

and

$$Covid\ CFR_d = \gamma_0 + \gamma_1 Overnutrion\ indicators_d + \epsilon_i \qquad (5)$$

Table 3 reports the results and shows that the prevalence of COVID is significantly higher in districts with higher rates of over-nutrition and the correlation is stronger when obesity is used as a measure of over-nutrition, corroborating results using state-level analysis.

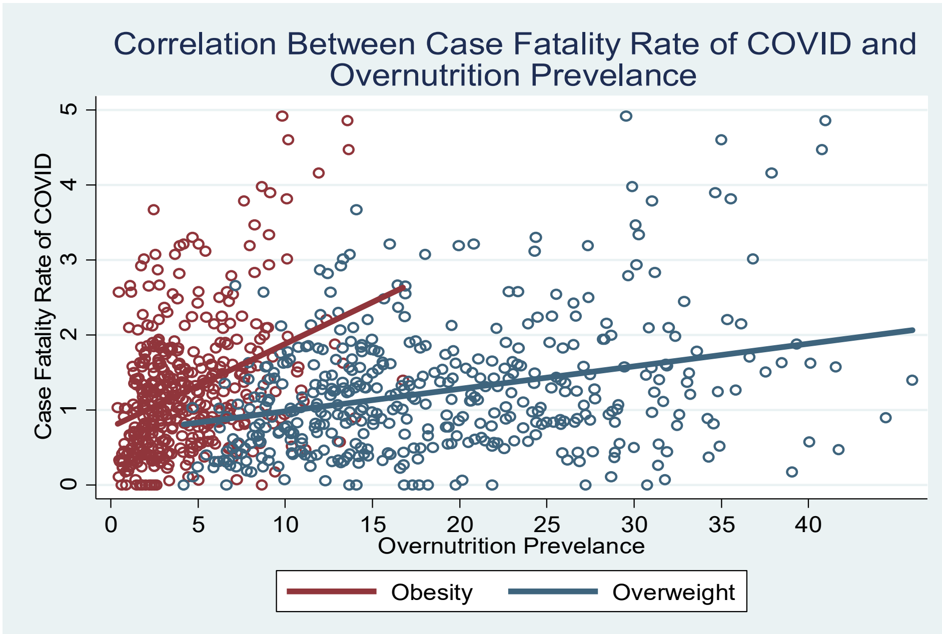
Table 3: Regression of incidence of COVID on the prevalence of overweight and obesity: District-level Estimates

Over-nutrition Indicators	**Dependent variable is prevalence rate of COVID**	**Dependent variable is prevalence rate of COVID**
Prevalence of Overweight	0.389***	-----
	(0.079)	
Prevalence of Obesity	-----	1.051***
		(0.246)
Observations	424	424

Note: Individual is defined as overweight when BMI ≥25 kg/m^2 and obese when BMI ≥30 kg/m^2. Standard errors in parenthesis. Significance: * p < 0.10, ** p < 0.05, *** p <0.01.
Source: Based on unit record data of the fourth round of National Family Health Survey conducted in 2015-16 and COVID data is obtained from government sources.

Next, the CFR of COVID in a district is regressed on the proportion of overweight and obese individuals in the particular district and Figure 7 represent the predicted values. Results indicate a positive and significant relationship, and as expected the correlation is stronger where the prevalence of obese individuals is higher.

Figure 7: Association between Case Fatality Rate (CFR) of COVID and Overweight and Obesity Prevalence: District-level analysis



Note: Individual is defined as overweight when BMI ≥25 kg/m^2 and obese when BMI ≥30 kg/m^2.
Sources: Based on unit record data of the fourth round of National Family Health Survey conducted in 2015-16 and COVID data is obtained from government sources.

7. Summary and Conclusions

This paper explores the association of over-nutrition with COVID prevalence and COVID CFR respectively for India and finds a significant association between markers of over-nutrition - being overweight and obese - on COVID parameters, for both states and districts, but the relationship is more robust at the district-level. The results corroborate other global results and indicate that COVID has added another dimension to the prevalence of over-nutrition, making it imperative for policymakers to take this into consideration in their interventions and programmes.

India has been seeing an increase in over-nutrition over recent years. With the added dimension of COVID, movements including exercise have been restricted and have aggravated sedentary lifestyle. Some evidence exists to suggest increased consumption of processed food during lockdown has escalated the risk of being overweight and obese.[4] While the various health implications of being overweight are now well-known, the positive link between ill health and high death rates from COVID infection with being overweight needs to be conveyed to the public to lend urgency to prevention and promotion measures taken by individuals. The added angle of lower efficacy of COVID vaccines on overweight/obese individuals and the possibility of such vaccines producing fewer antibodies requiring additional booster dose among this population cannot be ruled out (Pellini et al., 2021). These results suggest that obese and overweight individuals may be another group that can be prioritized for COVID vaccination.

These results provide an added urgency to government programmes and interventions around nutrition as well as NCDs. While there are several best practices available around the globe on prevention of NCDs like taxes on unhealthy food etc, more nuanced programmes including information, education and communication strategies can be added to address the issues around weight control and obesity.

[4] https://www.livemint.com/news/india/lockdown-consumers-focus-shifts-to-packaged-high-value-food-items-11588502080697.html. Accessed on March 10, 2021.

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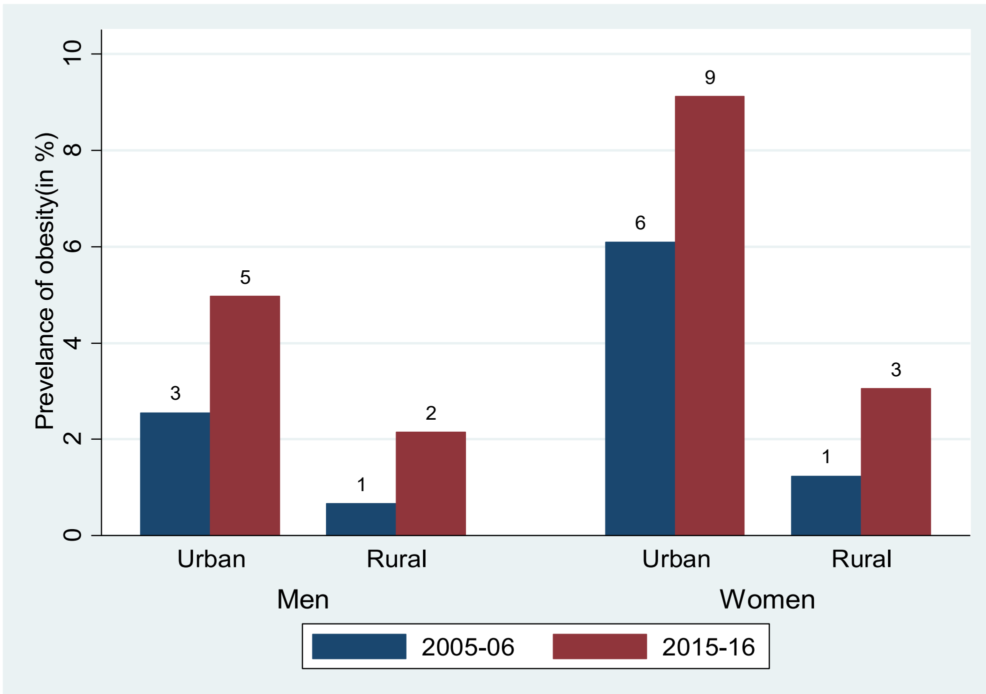
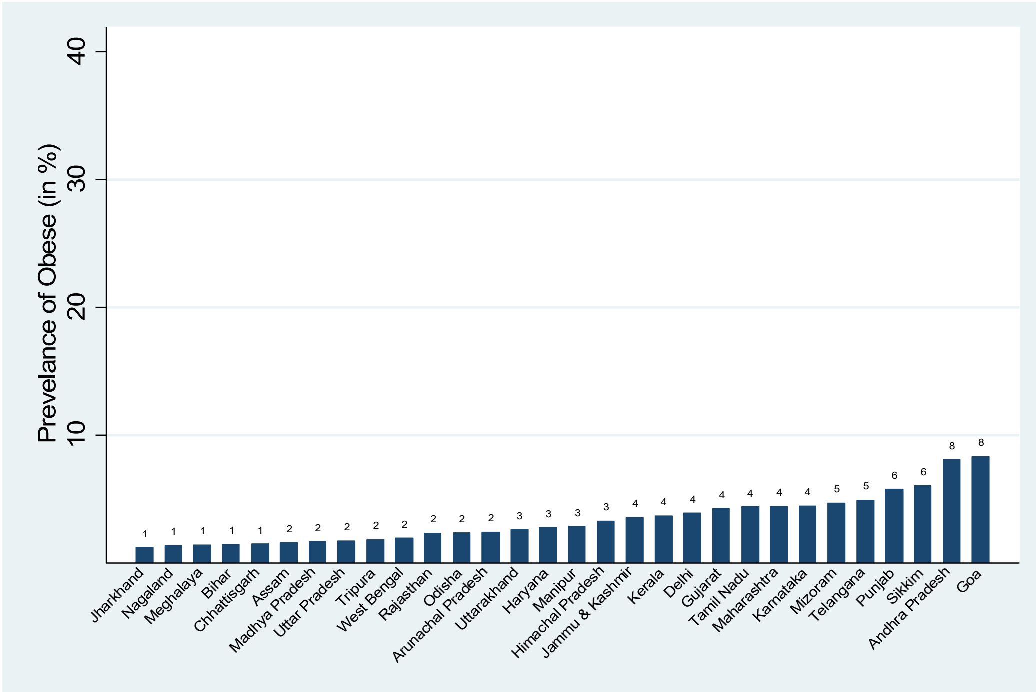
Appendix

Figure A1: Prevalence of Obesity, by Type of Residence and Gender(in %)



Notes: Data refer to men aged 15 to 54 years and women aged 15-49 years. Adult is classified as overweight/obese if his/her BMI is ≥30 kilograms per meters squared.
Sources: 2005-06 and 2015–2016 data are computed from the unit record data of the third and fourth rounds of the National Family Health Survey.

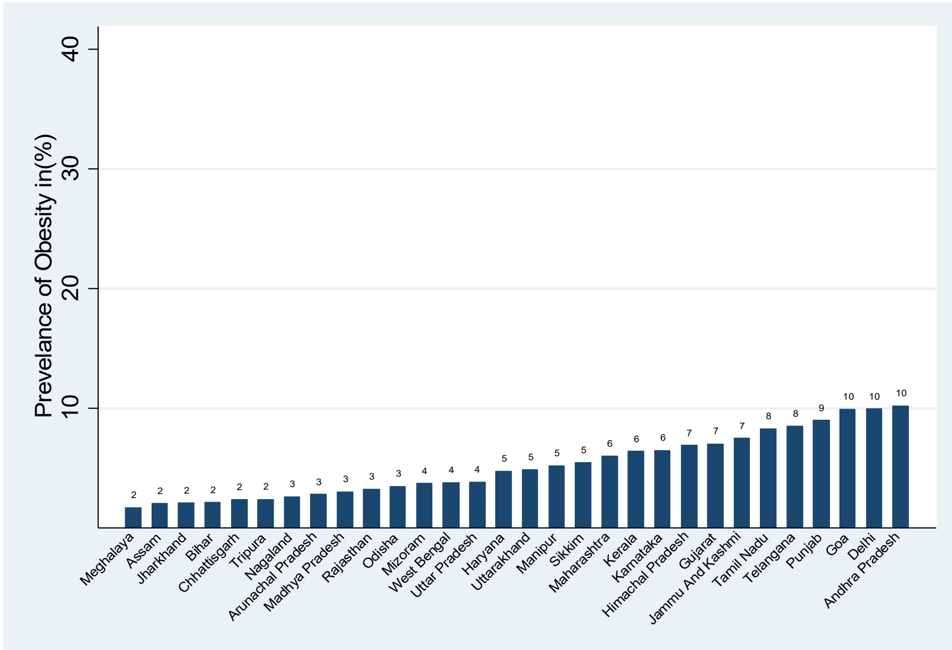
Figure A2: Prevalence of Obesity among Men in 2015-16, by State(in %)



Notes: Data refer to men aged 15 to 54 years. Adult is classified as obese if his BMI is ≥30 kilograms per meters squared.

Sources: Data is computed from the unit record data of the fourth round of the National Family Health Survey conducted in 2015-16.

Figure A3: Prevalence of Obesity among Women in 2015-16, by State(in %)



Notes: Data refer to women aged 15 to 49 years. Adult is classified as obese if her BMI is ≥30 kilograms per meters squared.

Sources: Data is computed from the unit record data of the fourth round of the National Family Health Survey conducted in 2015-16.

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