Prevalence and Correlates of Overweight and Obesity in Adults and Older Adults in India; Population-Level Estimates Based on Nationally Representative Surveys (2015-21)

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In the current epidemiological transition, a rapid increase in the prevalence of overweight is observed in low-middle-income countries. There is a prominent shift towards a sedentary lifestyle and unhealthy food consumption which has triggered the risk of NCDs. The situation is similar in India. A holistic understanding of obesity epidemiology is the need of the hour with a target-oriented intervention approach. Though multiple studies have been a part of the research pool, insights are limited in the case of the whole prevalence as per the National estimate. This study attempts to understand the epidemiology of overweight/obesity in India concerning the entire population. The study is unique in the sense that it utilizes National-level estimates to understand the epidemiology of obesity concerning the entire population. It aims to explore the state-level prevalence of overweight/obesity and understand the implications as per socio-economic indicators and age-sex groups. The study takes up cross-sectional analysis, using two National Representative data sets. It identifies key anthropometric parameters and socio-economic correlates to run descriptive analysis and logistic regression. The descriptive analysis provided us with the age-sex prevalence of obesity, while logistic regression was used to establish the SES gradient by age. Lastly, to measure the inequality of obesity among males and females by different age groups, concentration indices is used. The findings reveal a higher prevalence of overweight/obesity among females than males. The prevalence among females is 19.2 percent, whereas it is 16.8 percent in the case of males. The highest prevalence is observed in NCT Delhi (33.9%) and the lowest in Meghalaya (10%). With respect to socio-economic determinants, the prevalence is noticeably higher among those residing in urban areas, belonging to the richest wealth index, identifying in the 'others' social groups and who have 10 or more years of education across the age groups. The paper presents all-inclusive results of obesity/overweight epidemiology in India, giving a holistic understanding of obesity implications with regard to age and SES-wise determinants. Thus, providing probable pathways for intervention.

Keywords: Obesity, Overweight, India, Nutrition, Body Mass Index

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For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://healthempirics.org/

The rapid increase in the prevalence of overweight/obesity in low- and middle-income countries (LMICs) is a more relatively recent trend globally (McLachlan & NCD-RisC, 2016). An increase has been noted in both rural and urban areas, with the rural areas displaying a recent pattern of intensified escalation (NCD- RisC, 2019). The rise in overweight and obesity rates across age groups has been relatively higher in LMICs and plateauing in high-income countries (HICs). As of 2016, over two billion (70%) globally overweight or obese individuals, reside in LMICs (Abay et al., 2022). While the major direct cause is the rapid increase in consumption of ultra-processed food along with other junk foods high in added saturated fats, sodium and sugar, underlying factors include rapid social and economic changes such as urbanisation, globalization, and economic growth accompanied by increased income per capita (Wen et al., 2009). Increased sedentary living occurred earlier and now it is the diet that directly impacts these changes (Popkin & Ng, 2022). Certain subpopulations also experience the dual challenge of malnutrition, resulting in both hunger-induced undernutrition and stunting. The rising consumption of ultra-processed food and beverages, and increased prevalence of overweight and obesity have triggered the risks of multiple Non-Communicable Diseases (NCDs) such as cardiovascular diseases (CVDs), diabetes, hypertension and 13 of the 16 major cancers (WCRF & AICR, 2018). The increased mortality from CVD and cancer is also very concerning (Popkin, 2003). Over the last few decades, the prevalence of NCDs has sharply increased in many LMICs, while it is somewhat declining in the HICs (Abdelaal et al., 2017).

India is going through a similar nutrition transition (Popkin & Ng, 2022). Amidst rapid economic growth and income development, the prevalence of overweight/obesity and associated NCDs has been consistently increasing across all age groups and regions in India (Miranda et al., 2019). Moreover, the figures are expected to triple among Indian adults (20-69 years) between 2010 and 2040 with higher risk among the rural residents and older Indians, if not intervened timely (Ranjani et al., 2016). This is mainly linked with the rapid increase in consumption of ultra-processed food by the Indian population, particularly those under 40 years of age.

The cross-sectional analysis presented in this study has a two-fold advantage. Firstly, it provides evidence on the age group where the rise of obesity prevalence is triggered. Secondly, when compared with lagged estimates across the age-sex group, it can provide an understanding of metabolic problems accumulating over time. More importantly, the paper is an insight into the reliability of the outcomes as obtained from using 2 different data sets positioned in different time frames. Though the issue being addressed here is very pertinent to public health, the current data repository on obesity may not potentially produce a reliable glimpse of the actual epidemiological status. It is established that the pattern of BMI changes in accordance with age (Luhar et al., 2020). Thus, for ideal quantification, taking up a life course pattern is critical to understanding the magnitude of the burden.

Currently, the literature on prevalence and correlates has mostly focused on socioeconomic status (SES) and its association with overweight and obesity. Studies have reported a positive association between SES indicators and obesity across age groups (Neuman et al., 2013). However, evidence suggests that the association vary by economic development, region, and gender within countries (Monteiro et al., 2004). There is a complex linkage between SES levels and obesity. While decades ago, SES in LMICs was linked positively with obesity, more recently the shifts have been complex and many countries such as China, Indonesia, and others have higher levels of obesity among the poor than the higher SES groups (Popkin et al., 2020).

In LMICs, a positive association is likely across age groups and sex (adult men and women and children), while in developed countries, a negative association is more common among women (inconsistent in men and children) (Pavela et al., 2016). A recent review by Templin et al., (2019), reveals that as national economies increase to higher levels, the burden of overweight/obesity shifts over time to poorer sections of the population within these countries. The impact factor shows a considerable increase in prevalence amongst the poorer sections of the population whilst, for the wealthiest sub-populations, the prevalence rate remains more or less unchanged (Cohen et al., 2013).

The present paper answers the following research questions specifically for adults and older adults using India's two nationally representative surveys: (a) What is the prevalence of overweight/obesity in India? (b) Are wealthy/educated more likely to be overweight/obese in India? (c) Whether thinning set in earlier for men than women? (d) Whether the current data set is reliable for quantifying the magnitude of obesity in India?

The question aims to understand the epidemiology of overweight/obesity in India concerning the entire population. It takes into consideration the respective age-sex groups, their experiences and socio-economic status. To round up the analysis and its implications we also explore the state-level associations of overweight/obesity prevalence.

Methodology

- **Study Design**

The study is a cross-sectional analytical study using two National Representative data sets. It identifies anthropometric parameters and socio-economic correlates to run descriptive analysis and logistic regression. Additionally, an "Obesity Tree/ Pyramid" depicting age-sex-wise prevalence was also plotted.

- **Variables**

The main variables used are the anthropometric parameters to estimate the prevalence of overweight and obesity. WHO adult BMI cut-offs, BMI for age Z score (BAZ), and weight-for-height Z-score (WHZ) as per WHO standard are used for adults respectively. Body mass index (BMI) is defined as a person's weight in kilograms divided by the square of the height in meters (kg/m2) that is commonly used to classify overweight and obesity in adults (Pavela et al., 2016)..

For adults (all ages), WHO defines overweight as BMI >= 25 and obesity as BMI >= 30 (Templin et al., 2019).

Alternate measures to identify abdominal obesity in adults i.e., waist-to-hip ratio were also used. In accordance with the WHO, a waist-to-hip ratio above 90 cm in men and >85 cm in women is classified as abdominal obesity.

Other background variables used in the analysis consisted of a few correlates including socioeconomic factors including i) place of residence (urban/rural); ii) wealth quintiles as poorest, poor, middle, rich and richest; iii) social groups as SC, ST, OBC and 'Others' and iv) education in years as <5 years, 5-9 years and 10 years and more.

- **Data Sources**

The study is based on nationally representative surveys namely National Family Health Survey (NFHS), 2019-21, and Longitudinal Ageing Study in India (LASI) Wave 1, 2020. A brief overview of the surveys is given below.

- **National Family Health Survey, 2019-21**

The National Family Health Survey, 2019-21 survey was conducted by International Institute for Population Sciences (IIPS), Mumbai across all India's States and UTs using a two-stage, stratified cluster sample, wherein 724,115 women (15-49 years) and 101,839 men (15-54 years) were selected from a random sample of 636,699 households. The survey yielded an analytical sample of 423843 adult women (20–49 years) and 65196 men (20–49 years) after adjusting missing data which were used in the present analysis. For more information on the sampling procedure of the NFHS-2019-2021 survey, visit the link http://rchiips.org/nfhs/NFHS-5Reports/NFHS-5_INDIA_REPORT.pdf

- **Longitudinal Ageing Study in India (LASI) Wave 1, 2017-19**

Longitudinal Ageing Study in India (LASI) 2020 (Wave-I) is a nationally demonstrative survey of the health, economic, and social determinants and consequences of older adults (45 and above years) and population ageing in India. The LASI Wave 1 was conducted across India's States and UTs (excluding Sikkim) by International Institute for Population Sciences (IIPS), Mumbai using a stratified,

multistage stratified area probability cluster sampling design wherein 72,250 older adults and elderly men and women aged 45 and above were selected.

The present study used 45105 observations after adjusting missing data of the older population who were 50 and above years. For more information on the sampling design and method of the LASI-2020 (Wave-I) survey, visit the link https://www.iipsindia.ac.in/content/lasi-publications, https://www.iipsindia.ac.in/content/lasi-publications.

- **Statistical methods**

Descriptive statistics were conducted to estimate prevalence by correlates. To estimate the state-level prevalence of obesity, NFHS-4 data were used for 15-49 years, and LASI datasets for 50-59 years, 60-69 years and 70 years and above. The weighted prevalence population data for 2021 was obtained from the Population Projection Report 2011-2036. The share for each age group was calculated in the total population which served as weights to calculate the weighted prevalence. This was done at both the national and the State levels.

Logistic regression analyses were carried out; the odds ratio for correlates to establish the SES gradient by age. Interactions of wealth quintile/education to examine the SES gradient by age have also been made. To measure the inequality of obesity among males and females by different age groups we have used the concentration indices.

Results

Among the male population, the prevalence of obesity increases with age up to 40-49 years and starts to decline thereafter. Whereas, among females, the percentage of obesity increases up to the age of 50-54 years and declines after that. The overall prevalence of overweight and obesity is 17 percent among 20-29 years, 31.7 percent among 30-39 years, 36.4 percent among 40-49 years, 32 percent among 50-59 years, 25.3 percent among 60-69 years and 16.9 percent among >=70 years (Table 1). As per the SES determinants, the prevalence is comparatively higher among those belonging to urban areas, the richest community, 'others' social groups and higher education experience. (Table 1). Hereafter we use the term obesity but it combines both overweight and obesity. We combined the figures as in India the risk of diabetes and many other NCDs rises at a BMI of 22 (Wen et al., 2009).

The prevalence of obesity is highest in Delhi (33.9 %) with females accounting for 37.3 percent and males accounting for 30.9 percent. The prevalence is lowest in Meghalaya (10 %) with females having a 9.9 percent prevalence rate and males recording 10.5 percent (Table 2).

Table 1: Age-group-wise prevalence of overweight and obesity by SES for total population

Background Variables	20-29 Years	30-39 Years	40-49 Years	50-59 Years	60-69 Years	>=70+ Years
Place of residence	**%**	**%**	**%**	**%**	**%**	**%**
Urban	22.8	41.9	48.3	52.4	43.3	32.6
Rural	14.3	26.6	30.3	22.8	18.2	11.1
Wealth Index						
Poorest	7.3	13.7	16.0	23.1	16.3	10.6
Poor	12.1	22.8	24.8	27.2	21	13.1
Middle	17.0	31.7	35.1	29.4	25	17
Rich	21.2	40.4	44.4	35.3	31.9	19.4
Richest	26.0	47.7	55.9	47.4	35.4	27.6
Social Groups						
SC	15.7	29.4	32.6	22.8	19.2	9.1
ST	9.1	17.5	20.1	15.4	8.8	5.5
OBC	17.4	32.8	37.7	36	26.2	19
Others	20.4	37.1	42.3	38.7	34.2	22
Education in years						
No schooling	10.3	20.6	26.9	23.4	17.9	11.3
<5 years	12.3	24.9	33.3	24.2	24.1	19
5-9 years	16.0	32.6	41.1	37.6	32.8	20.2
10+ years	19.1	40.9	49.0	51.3	42.2	39.5
Total	17.0	31.7	36.4	32	25.3	16.9

Note- N is the weighted total sample.

The values of concentration indices are positive across all age groups indicating that overweight/obesity is concentrated among the wealthy population as compared to the poor (Table 3).

It is observed that the odds of obesity were greater for urban dwellers as compared to their rural counterparts. For urban adults aged 20-29 and 30-39 years, odds are 1.18 (95% CI: 1.15-1.21) and 1.14 (95% CI: 1.11,1.16) times the odds of obesity. The figure is similar for adults aged 40-49 years i.e., 1.20 times. The odds go comparatively higher for older adults and the elderly. Within the age group 50-59, 60-69 and 70+, there are 2.61 (95%, CI: 2.43, 2.80), 2.64 (95% CI: 2.45, 2.86) and 2.86 (95% CI: 2.56, 3.19) times the odds of obesity, respectively (Table 4). At the same time, it is important to note the rapid increases in rural obesity over the past decade (NCD- RisC, 2019).

As per the wealth index, the odds of obesity are higher for the wealthier population. This section states the odds as compared between the poorest and the richest. The richest adults belonging to age groups 20-29, 30-39 and 40-49 years had 3.93

Table 2: State standard estimates of obesity and overweight

State/UT	Male %	Female %	Total %
Andhra Pradesh	25.7	31.9	28.8
Assam	13.9	13.4	13.7
Bihar	11.5	11.8	11.6
Chhattisgarh	12.7	11.4	12.1
Gujarat	16.8	21.9	19.2
Haryana	21.5	25.7	23.5
Himachal Pradesh	23.9	29.1	26.5
Jammu & Kashmir	24.8	27.9	26.2
Jharkhand	11.1	9.6	10.4
Karnataka	26.1	30.1	28.1
Kerala	28.0	34.7	31.4
Madhya Pradesh	12.4	13.4	12.8
Maharashtra	20.5	22.7	21.5
NCT Of Delhi	30.9	37.3	33.9
Odisha	18.0	17.7	17.2
Punjab	27.9	37.0	32.2
Rajasthan	12.2	12.5	12.4
Tamil Nadu	27.6	33.9	30.7
Telangana	23.4	24.9	24.1
Uttar Pradesh	13.8	16.3	15.0
Uttarakhand	21.9	24.3	23.1
West Bengal	15.6	18.8	17.1
Arunachal Pradesh	20.9	19.4	20
Goa	26.8	32.9	30
Manipur	23.3	26.7	25
Meghalaya	10.5	9.9	10
Mizoram	22.6	17.9	20
Nagaland	18.9	14.5	17
Sikkim	NA	NA	NA
Tripura	18.5	17.1	18

(95% CI: 3.70, 4.07), 4.41 (95% CI: 4.23, 4.58) and 4.95 (95% CI: 4.84, 5.25) times the odds of obesity, respectively. In the same wealth index, older adults and the elderly aged 50–59, 60–69 and 70+ years accounted for comparatively lesser odds of obesity i.e., 2.38 (95% CI: 2.14, 2.66), 2.36 (95% CI: 2.09, 2.66) and 2.44 (95% CI: 2.04, 2.91), respectively.

Concerning social identity, it is observed that the likelihood of obesity in the category of ‘others’ is higher than those belonging to the Scheduled Caste category.

Table 3: Concentration index values for the total population

Age group	Index value	Std. error	p-value	No. of obs.
20 to 29 years	0.23	0.00	0.00	232154
30 to 39 years	0.23	0.00	0.00	212355
40 to 49 years	0.23	0.00	0.00	180963
50 to 59 years	0.14	0.01	0.00	18225
60 to 69 years	0.15	0.01	0.00	16529
70+ years	0.18	0.01	0.00	10351

Table 4: Logistic regression on overweight and obesity by SES for total population

Background Variables	20-29 Years	30-39 Years	40-49 Years	50-59 Years	60-69 Years	>=70+ Years
Place of residence						
OR [95%, C.I.]						
Rural	1	1	1	1	1	1
Urban	1.18***	26.6	30.3	22.8	18.2	11.1
Wealth Index						
Poorest	1	1	1	1	1	1
Poor	''1.69*** [1.62, 1.77]''	''1.77*** [1.71, 1.84]''	''1.66*** [1.60, 1.72]''	1.19** [1.07, 1.33]	1.26*** [1.11, 1.42]	''1.29** [1.08, 1.54]''
Middle	''2.42*** [2.31, 2.53]''	''2.59*** [2.50, 2.68]''	''2.50*** [2.41, 2.59]''	1.33*** [1.19, 1.49]	1.51*** [1.34, 1.71]	1.52*** [1.27, 1.81]
Rich	''3.10*** [2.95, 3.25]''	''3.43*** [3.30, 3.56]''	''3.43*** [3.29, 3.56]''	1.72*** [1.55, 1.92]	1.96*** [1.74, 2.21]	2.08*** [1.75, 2.48]
Richest	3.93***[3.74, 4.14]	4.41***[4.23, 4.60]	4.95***[4.74, 5.17]	2.38*** [2.14, 2.66]	2.36*** [2.09, 2.66]	2.44*** [2.04, 2.91]
Social Groups						
SC	1	1	1	1	1	1
ST	''0.82*** [0.79, 0.85]''	''0.75*** [0.73, 0.78]''	''0.82*** [0.79, 0.85]''	0.72*** [0.64, 0.81]	0.77*** [0.67, 0.88]	0.81 [0.66, 1.00]
OBC	''1.01 [0.98, 1.04]''	''0.95*** [0.93, 0.98]''	''0.99 [0.96, 1.02]''	1.18*** [1.07, 1.30]	1.25*** [1.12, 1.39]	''1.21* [1.02, 1.43]''
Others	''1.17*** [1.13, 1.21]''	''1.09*** [1.06, 1.12]''	''1.11*** [1.08, 1.15]''	1.49*** [1.34, 1.65]	1.47*** [1.30, 1.65]	1.49*** [1.25, 1.78]
Education						
No schooling	1	1	1	1	1	1
<5 years	''1.08 [1.00, 1.17]''	''1.12*** [1.07, 1.18]''	''1.17*** [1.13, 1.22]''	''1.00 [0.90, 1.13]''	1.20** [1.07, 1.36]	''1.20* [1.03, 1.41]''
5-9 years	''1.18*** [1.13, 1.24]''	''1.30*** [1.26, 1.33]''	''1.28*** [1.25, 1.32]''	1.43*** [1.32, 1.56]	1.45*** [1.32, 1.59]	''1.22** [1.05, 1.40]''
10 years & more	''1.10*** [1.05, 1.15]''	''1.33*** [1.29, 1.37]''	''1.34*** [1.30, 1.38]''	1.59*** [1.44, 1.74]	1.69*** [1.53, 1.88]	1.53*** [1.31, 1.78]

Note- P <0.01***, P <0.05** and *<0.10

Table 5: Logistic regression of Interactions between years of schooling and wealth index for total population on obesity

Schooling years and wealth	20–29 years	30–39 years	40–49 years	50–59 years	60–69 years	70+ years
	OR [95%, C.I.]	OR [95%, C.I.]	OR [95%, C.I.]	OR [95%, C.I.]	OR [95%, C.I.]	OR [95%, C.I.]
No school & poorest	1	1	1	1	1	1
No school & poorer	1.77***[1.59, 1.96]	1.96***[1.86, 2.08]	1.71***[1.63, 1.80]	1.15 [0.98, 1.35]	1.32** [1.11, 1.56]	1.39** [1.10, 1.76]
No school & middle	2.64***[2.35, 2.96]	2.92***[2.75, 3.10]	2.68***[2.56, 2.82]	1.41*** [1.21, 1.66]	1.74*** [1.47, 2.06]	1.73*** [1.37, 2.17]
No school & richer	3.96***[3.47, 4.53]	4.45***[4.15, 4.77]	3.88***[3.68, 4.09]	1.81*** [1.55, 2.12]	2.15*** [1.81, 2.54]	2.12*** [1.69, 2.66]
No school & richest	4.87***[4.02, 5.90]	5.98***[5.41, 6.61]	6.08***[5.69, 6.51]	2.38*** [2.02, 2.80]	2.62*** [2.20, 3.12]	2.74*** [2.16, 3.47]
<5 years & poorest	1.06[0.91, 1.23]	1.20***[1.09, 1.32]	1.07[0.97, 1.19]	1.17 [0.90, 1.51]	1.61*** [1.22, 2.11]	1.71** [1.18, 2.46]
<5 years & poorer	1.95***[1.69, 2.25]	2.05***[1.88, 2.24]	2.07***[1.91, 2.24]	1.28* [1.01, 1.64]	1.95*** [1.52, 2.50]	1.76** [1.23, 2.52]
<5 years & middle	2.86***[2.43, 3.37]	3.42***[3.13, 3.74]	3.16***[2.93, 3.42]	1.56*** [1.23, 1.98]	2.25*** [1.76, 2.89]	1.96*** [1.37, 2.80]
<5 years & richer	4.03***[3.31, 4.90]	4.68***[4.20, 5.23]	4.68***[4.29, 5.10]	1.82*** [1.44, 2.29]	3.00*** [2.33, 3.87]	3.13*** [2.27, 4.31]
<5 years & richest	6.56***[4.86, 8.86]	6.39***[5.32, 7.68]	6.99***[6.12, 7.98]	3.02*** [2.38, 3.83]	3.15*** [2.43, 4.09]	4.48*** [3.26, 6.14]
5 9years & poorest	1.16**[1.06, 1.28]	1.41***[1.32, 1.50]	1.34***[1.24, 1.45]	2.02*** [1.68, 2.44]	2.42*** [1.95, 3.01]	2.29*** [1.61, 3.26]
5 9years & poorer	2.08***[1.91, 2.26]	2.45***[2.32, 2.58]	2.16***[2.05, 2.29]	2.41*** [2.03, 2.86]	2.87*** [2.35, 3.50]	2.56*** [1.88, 3.48]
5 9years & middle	3.27***[3.00, 3.55]	3.84***[3.65, 4.04]	3.42***[3.25, 3.60]	2.66*** [2.24, 3.16]	2.88*** [2.37, 3.50]	2.35*** [1.73, 3.20]
5 9years & richer	4.29***[3.93, 4.67]	5.31***[5.04, 5.60]	4.97***[4.73, 5.23]	3.36*** [2.85, 3.96]	3.70*** [3.05, 4.48]	3.62*** [2.73, 4.82]
5 9years & richest	5.57***[5.05, 6.15]	7.33***[6.91, 7.79]	7.91***[7.48, 8.35]	3.92*** [3.32, 4.62]	4.32*** [3.57, 5.24]	3.60*** [2.67, 4.85]
10+more & poorest	1.21***[1.09, 1.35]	1.73***[1.56, 1.93]	1.49***[1.28, 1.73]	3.39*** [2.66, 4.33]	3.72*** [2.81, 4.91]	2.97*** [1.87, 4.73]
10+more & poorer	2.02***[1.85, 2.19]	2.80***[2.62, 2.99]	2.53***[2.33, 2.75]	3.42*** [2.78, 4.21]	4.27*** [3.37, 5.42]	3.75*** [2.58, 5.44]
10+more # middle	2.86***[2.64, 3.10]	3.87***[3.67, 4.09]	3.79***[3.56, 4.04]	3.23*** [2.67, 3.92]	4.49*** [3.64, 5.54]	4.56*** [3.30, 6.31]
10+more& richer	3.89***[3.60, 4.20]	5.25***[5.00, 5.52]	5.24***[4.97, 5.52]	4.34*** [3.66, 5.15]	5.35*** [4.40, 6.52]	6.17*** [4.64, 8.22]
10+more & richest	5.36***[4.97, 5.79]	7.32***[6.98, 7.67]	8.01***[7.65, 8.39]	5.79*** [4.96, 6.76]	6.71*** [5.63, 8.01]	6.24*** [4.85, 8.01]

Note- P <0.01***, P <0.05** and *<0.10

Adults in the 'others' category, aged 20-29, 30-39 and 40-49 years have 1.17 (95% CI: 1.12, 1.20), 1.09 (95% CI: 1.06, 1.12) and 1.11(95% CI: 1.08, 1.15) times higher odds of obesity, respectively. Lastly, older adults and elderly aged 50-59 (95% CI: 1.34,1.65) and 70+ years (95% CI: 1.25,1.78) have 1.47 times and 1.49 times the odds of obesity, respectively.

Education being the final determinant, the propensity of obesity is higher among the population having ten or more years of education. Obesity holds 1.10 times higher odds among adults aged 20-29 years (95% CI: 1.08,1.18), having ten years and more education. The odds are 1.33 and 1.34 for age groups 30-39 and 40-49 years, respectively, within the same education parameter. Among the older adults and the elderly, the population aged 50-59, 60-69 and 70+ years have 1.59 (95% CI: 1.44, 1.74), 1.69 (95% CI: 1.53, 1.88) and 1.53 (95% CI: 1.31, 1.78) times the odds of obesity.

Table 5 shows the logistic regression between the level of education (in years) and the wealth index on obesity for the total population. Interaction analysis reports that those with an education of ten or more years and belonging to the richest section were significantly more likely to be obese as compared to those who had no education and belonged to the poorest wealth index.

Discussion

According to the available data, this study is a one-of-a-kind insight into the epidemiology of obesity/overweight in India. It uses two nationally representative surveys. This paper also provides India-based evidence on the association of overweight/obesity with SES indicators (income and education) by sex.

- **Key Findings**

The analysis reveals that the national prevalence of obesity across age groups is 19.2 percent in females which is sufficiently higher than in males who record a figure of 16.8 percent. The highest prevalence is observed in NCT Delhi and the lowest in Meghalaya. The prevalence is noticeably higher among those residing in urban areas, belonging to the richest wealth index, identifying in the 'others' social groups and who have 10 or more years of education across the age groups.

Thus, it is evident from the findings that the prevalence of overweight/obesity among females is higher than in males. In adults and adolescents in developing countries, a higher prevalence of obesity was seen among females, while in developed countries, the case was essentially the opposite (Mistry & Puthussery, 2015; Garrido-Miguel et al., 2019). This study estimates national overweight/obesity prevalence across all age groups. There are twofold advantages to estimating the national level prevalence i.e.; (a) It reveals a particular age group which requires priority focus

by the national programs and policies and (b) It provides an understanding of the metabolic factors accumulating over time when compared with lagged estimates across the age-sex groups.

A consistent gender disadvantage in obesity in adulthood was observed in our study. This is in line with the findings from the studies from other LMICs, where they found a much higher prevalence of obesity in women aged 20 years and above than in men (Skinner et al., 2018). The most common explanations regarding gender disparities in overweight and obesity were physical activity, cultural values, biological factors (e.g., menopause), and urbanization (Mistry & Puthussery, 2015). In contrast, Ameye & Swinnen (2019) suggests an absence of a significant gender difference in average obesity prevalence in high-income level countries. Additionally, there's a reversal of the obesity gap in high-income level countries, with males becoming the more obese gender in Japan, Scandinavian countries, and in Northern European countries like Belgium, France, Switzerland and Germany (Kanter & Caballero, 2012).

A positive SES gradient was observed for females where the prevalence of obesity increased with increasing education level and wealth quintile, which is also in line with earlier evidence from India (Bhurtyal & Adhikari, 2022). Indian studies have linked this to cultural norms that may favour fat body shapes, higher consumption of energy-dense diets, and traditional narratives which bars high-SES women in India to engage in physical activities and healthy dietary practices, despite more knowledge, awareness and resources (Kanter & Caballero, 2012). Our finding slightly deviates from the findings in developing countries. It has been observed that the women with higher SES throughout their life, have lower BMI, and the findings among men were less consistent (Ameye & Swinnen, 2019). These could be attributed to having weight-related standards among wealthy females resulting in regular exercise and healthy diets, which are of course easier to maintain with higher income.

A meta-analysis of prospective cohort studies found that individuals with obesity were associated with a 7- and 3-times higher risk of diabetes and being overweight respectively, as compared to normal-weight individuals (Abdullah et al., 2010). Our analysis found positive associations among overweight/obesity, NCD burden and out-of-pocket health expenditure. Therefore, addressing the growing overweight and obesity prevalence is of great urgency. Preventive measures such as screening for NCDs like diabetes and hypertension among overweight/obese individuals especially. among high-risk individuals should be integrated into the health system. The existing government initiatives such as the National Multisectoral Action Plan for Prevention and Control of NCDs (2017-22), which partly aims to reduce out-of-pocket expenditure on NCD healthcare should be implemented across India (Luhar et al., 2020)..

This section not only elaborates on the limits but also puts forth essential suggestions significant for obesity-related research. There are multiple issues which need to be kept in mind while considering the findings of this study. Firstly, the survey took into consideration a basic method of measurement i.e., BMI (derived from weight and height) to measure the prevalence of overweight and obesity. BMI is a measurement of only relative body weight, so it does not distinguish between body fat and lean mass. There are many other better alternate anthropometric measurements such as waist circumference and waist-to-hip ratio that are strongly associated with CVD risk factors (Goh et al., 2014) along with skinfold thickness which predicts body fat.

Secondly, we have used WHO's standard global adult cut-offs i.e., >=25 kg/m2 for overweight and BMI >= 30 for obesity. However, some studies have suggested that the proposed BMI standards aren't appropriate and the recommendation is to use lower BMI cut-offs for overweight/obese (≥23) and obese (≥25) for South Asians (Misra et al., 2009). This is because South Asians are at risk of developing obesity-related co-morbidities at lower levels of body mass index (BMI) and waist circumference (WC). Yet, we have chosen to use global cut-offs in order to ease the direct comparison with other studies.

Thirdly, the rising threat of obesity is alarming and a comprehensive understanding of it is thus important and relevant. The situation is equally precarious in India, and research minds have expressed the need for integrated data repositories for fruitful outcomes and forecastable status quo (world obesity report- India). The paucity of data at the population level makes estimation even more challenging. In spite of the impacts being significant population-wise, survey methods and data repositories have confined themselves to targeted age groups be it the children, elderly or reproductive women. Like poverty, obesity is associated with multiple causalities and consequences including social and economic points of view (Egger et al., 2012). However, though the former approaches the issue through National-level holistic estimates, the latter is mainly assessed along certain target groups. The similarity of the context of both issues suggests the adoption of alike approaches- in this case, using population-level estimates. This study intends to do the same by using the available datasets across each age group. However, the datasets being disintegrated are difficult to standardise. The standard deviation calculated for each State (Table S7) shows a wide range of dispersion ranging between 0.39 (Jharkhand) to 10.78 (Nagaland) among males and 0.19 (Madhya Pradesh) to 6.87 (Nagaland) among females. The high variability of the values questions the consistency of the outcomes, especially in order to generate meaningful population-level insights. The pooled data also had minor year variations.

The appropriateness of BMI as the standard measure for obesity across age groups has been a persistent topic of deliberation. Multiple studies note how physiological status among humans may vary with ageing, making obesity measurement

challenging (Goran, 1998). It is observed that ageing is associated with decreasing body weight and height. There is also the redistribution of adipose tissues along with a decrease in muscle mass (Batsis et al., 2016). These added complexities make it difficult to accurately diagnose obesity among the elderly, especially through the BMI index. In the study done by Batsis et al. (2016), the authors strategically emphasised the diagnostic inaccuracy of BMI application on elderly populations. Their findings show that BMI may fail to interpret adiposity, which is an important determinant among elderly populations. In a systematic and meta-analytical study carried out by Correa et al. (2016), the findings reveal that out of the 13 chosen articles, 5 manuscripts present evidence of the waist-to-height ratio (WHtR) being the "best anthropometric index" when applied alone.

The study also drew an association between obesity assessed via WHtR and the capacity to predict NCD risk factors, proving its efficiency greater than BMI. Similar criticism was obtained in the study conducted by Perissinotto et al. (2002). The cross-sectional analysis revealed the drawbacks associated with the standardization of homogenous anthropometric measurements to represent every age group. The paper investigates the cross-sectional sample of an elderly population and results show marked redistribution of body fat among the elderly. Since BMI does not quite reflect this redistribution, the homogenous BMI standards misinterpret obesity among elderly subjects. Ageing is usually coupled with an increase in fat mass and a decrease in fat-free mass. Thus, the threshold values in the case of the elderly population need careful re-considerations.

Despite the ongoing criticism, BMI continues to be the most frequently used index. It is not only an easy tool but has also predicted adverse outcomes in global scenarios. Though multiple studies have recommended alternate measurement indices, BMI along with waist circumference (WC) continue to receive special attention for analytical purposes. In fact, the systematic review by Correa et al (2016) also included two such studies which recognized WHtR, WC and BMI as having the same performance level.

Fourth is a limitation associated with interpreting cross-sectional association as one cannot draw any conclusions regarding causality out of the cross-sectional association.

Conclusion

In conclusion, the findings from our analysis show a higher prevalence of obesity in women compared to men, especially among those with higher socioeconomic status. The prevalence is also more pronounced among women and adults. This indicates that India is experiencing a rapid increase in overweight/obesity prevalence.

In addition, the presence of gender disadvantage (high prevalence in adult women) and positive SES gradient for females indicate where interventions should be targeted. Rapid urbanisation and economic growth, leading to shifting towards unhealthy food consumption, fatty diets, free sugars and/or salt and a sedentary lifestyle are the major causes of overweight and obesity globally. Therefore, implementing comprehensive food policies as recommended by the World Health Organization such as food and beverage taxes, marketing restrictions on unhealthy foods and beverages, and mandatory Front-of-Pack Labelling (FOPL) system with warning labels (which has worked wonders in Chile and Mexico, and among many other countries), should be implemented in India to control the obesogenic environment and promotion of healthy dietary habits.

All age groups in India are increasingly consuming excessive ultra-processed food which foretells a future increase in overweight/obesity and all nutrition-related NCDs. The strengthening, scaling up and redesigning of existing undernutrition-related interventions, programmes and policies can be done to tackle the growing burden of overweight and obesity. It is important to realize the increasing intake of ultra-processed food among infants and toddlers. A cost-effective approach known as double duty actions may be applied. Most importantly, we must find a way to reduce intake of ultra-processed food consumed by preschoolers (Pries et al., 2019). Thus, policies and programs in low and middle-income countries must prioritize safeguarding child nutrition through increased micronutrient intake and capping the heightened distribution of ultra-processed food and beverages.

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• **Supplementary Material:** Visit https://healthempirics.org/ for more information

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