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ORIGINAL RESEARCH

Factors Contributing to the Change in Overweight/Obesity Prevalence Among Indian Adults: A multivariate decomposition analysis of data from the National Family Health Surveys

Madhur Verma · Vandana Esht · Mohammed M. Alshehri · Mohammed Aljahni · Kirti Chauhan · Walaa E. Morsy · Nitin Kapoor · Sanjay Kalra

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ABSTRACT

Introduction: Concerns over the escalating burden of non-communicable diseases call for the redressal of behavioral risk factors like increased body mass index. Most studies have failed to quantify the contribution of socio-demographic characteristics in a linear trend. The present study aims to estimate the current prevalence of overweight and obesity in Indian adults and the contribution of different socio-demographic factors to the increasing prevalence.

Methods: We carried out a secondary data analysis of two National Family Health Survey (NFHS) rounds. The final sample includes 558,122 women and 84,477 men from round 4, and 574,099 women and 74,761 men were included from round 5, using a multi-stage stratified random sampling approach. Overweight/obesity was our primary dependent variable. Weighted bivariate analysis was used to ascertain the prevalence, and the adjusted

Madhur Verma and Vandana Esht are the co-first authors.

M. Verma
Department of Community and Family Medicine, All India Institute of Medical Sciences, Bathinda, India
e-mail: drmadhurverma@gmail.com

V. Esht (✉)
Physical Therapy Department, Jazan University, Jazan, Kingdom of Saudi Arabia
e-mail: vandanaesht@jazanu.edu.sa

M. M. Alshehri
Department of Physical Therapy, Faculty of Applied Medical Sciences, Jazan University, Jazan, Kingdom of Saudi Arabia
e-mail: moAlshehri@jazanu.edu.sa

M. Aljahni
Department of Physical Education, Jazan University, Jazan, Kingdom of Saudi Arabia
e-mail: maljahni@jazanu.edu.sa

K. Chauhan
Department of Biostatistics and Demography, International Institute for Population Sciences, Mumbai, India
e-mail: kirti070197@gmail.com

W. E. Morsy
Department of Physical Therapy, College of Applied Medical Sciences, Jazan University, Jazan, Kingdom of Saudi Arabia

W. E. Morsy
Department of Pediatrics, Faculty of Physical Therapy, Cairo University, Cario, Egypt
e-mail: morsy@jazanu.edu.sa

N. Kapoor
Department of Endocrinology, Diabetes and Metabolism, Christian Medical College, Vellore, India

odds ratios were computed to ascertain the potential predictors. The contribution of different factors towards rising burden over two time points was estimated using multivariate decomposition analysis for non-linear response models.

Results: Overall weighted prevalence of overweight and obesity in males and females per NFHS-5 was 44.02% and 41.16%, respectively, compared to 37.71% and 36.14% in NFHS-4. Decomposition analyses depict that the proportion of obesity increased by 6.37% and 5.10% points among men and women, respectively, over the two rounds. Compositional differences of participants (endowment) attributed to 16.54 and 49.90% differences, and the difference in coefficient or effect accounted for 83.46 and 50.10%, respectively, of the increase in the prevalence. The most significant factors contributing to increased prevalence were age, improving socio-economic status, smoking, unclean cooking fuel, and diabetes.

Conclusions: The incremental rise in such a short period, mainly attributed to the effect of socio-demographic variables, is concerning. Policy interventions should prioritize health advocacy programs and aggressively target behavioral modifications while preparing the health systems to manage the people living with obesity.

Keywords: Behavioral risk factors; Decomposition analysis; Non-communicable diseases; Obesity

Key Summary Points

Why carry out this study?

Overweight/obesity is rapidly escalating globally, along with associated comorbidities, and could overwhelm the health system in the future.

Previous research only highlighted factors that can significantly predict the occurrence of overweight/obesity, but few could depict the contribution of individual factors.

What was learned from the study?

Multivariate decomposition analysis depicted that the proportion of overweight/obesity increased by 5.95% and 4.13%, respectively, among men and women from 2015–2016 to 2019–2021.

The major portion of this increased prevalence is attributed to the changing effect of the socio-demographic overweight/obesity among men and women.

INTRODUCTION

With an increasing geriatric population in most countries, including India, non-communicable diseases (NCDs) continue to overwhelm our health system [1]. It is thus crucial to curtail the increasing prevalence of the most common risk factors for NCDs, like tobacco, alcohol, decreased physical activity, unhealthy diet, and high body mass index (BMI) [2]. Among these, overweight and obesity present considerable challenges to improving global health [3]. Excessive body weight-related ill-health accounted for over 5.0 million deaths globally in 2019, with more than half of these deaths occurring among people under 70 [2]. By 2030, it is predicted that 1 in 5 women and 1 in 7 men will be living with obesity (BMI $\geq$ 30 kg/m^2),

N. Kapoor
Non-Communicable Disease Unit, Baker Heart and Diabetes Institute, Melbourne, VIC, Australia
e-mail: nitin.endocrine@gmail.com

S. Kalra (✉)
Department of Endocrinology, Bharti Hospital, Karnal, India
e-mail: brideknl@gmail.com

S. Kalra
University Centre for Research and Development, Chandigarh University, Mohali, India

equating to over 1 billion people globally [4]. People living with overweight and obesity are likely to suffer from various life-threatening NCDs such as hypertension, diabetes, cardiovascular diseases, cancer, osteoarthritis, etc [3]. Considering this a major public health problem, the World Health Organization (WHO) aims to reduce global obesity to 2010 levels by 2025, and most countries are expected to fail to achieve their target [5]. Likewise, the target is threatened by the increasing prevalence of overweight and obesity in India, as the country alone harbors nearly a sixth of the global population.

India has seen a massive surge in the prevalence of overweight and obesity. As per our previous analysis, the prevalence of overweight and obesity among men and women in India, as per the fourth round of the National Family Health Survey (NFHS-4), was around 38.4% and 36.2%, respectively, depicting a relative change of 83.7%, and 54.7%, which is a serious cause for concern [6]. This increasing prevalence is usually attributable to recent economic progress along with demographic and nutritional transitions, urbanization, and dietary and lifestyle changes [7]. Therefore, it is essential to continuously study the epidemiology of overweight and obesity in India.

Previous research from India has mainly focused on determining the predictors of overweight and obesity using a basic logistic regression approach. These studies identified various determining factors, including age, gender, educational status, marital status, wealth status, household size, physical activity patterns, and regional differentials that were associated with overweight and obesity [8, 9]. A general problem (the decomposition problem) is to assess the contributions of changes or differences in the covariates between the two populations to the increase in the prevalence of overweight and obesity, which has not been appropriately quantified [10]. Not knowing the extent of these factors' contribution and impact restrains our policy priorities and, thus, resource allocation. Consequently, targeted policy adoption will be difficult. Therefore, to identify the extent of the contribution of different factors to the increase in overweight or obesity is of utmost important. Within this context, multivariate decomposition analysis can provide insights into the relative contribution of different factors to the increase in overweight/obesity prevalence [11]. This knowledge can inform evidence-based interventions, policies, and programs to reduce disparities and to promote better health outcomes for all individuals, irrespective of their socio-economic background, in India and countries undergoing similar epidemiological transitions. The NFHS allows us to study the epidemiology of overweight and obesity in Indian adults, as it is conducted frequently and includes a nationally representative sample size [12]. Thus, this study aims to estimate the current prevalence of overweight and obesity in Indian adults and to measure the contribution of different factors to the increasing prevalence of overweight and obesity among Indian adults over the last two rounds of NFHS.

METHODS

Data Source

The present study utilized data collected from the nationally representative cross-sectional surveys from the last two NFHS (rounds 4 and 5) conducted in 2015–2016 and 2019–2021 [12, 13]. The NFHS is the adopted demographic health survey version, and five survey rounds have been conducted since its inception in 1992–1993. This regular large-scale survey is conducted through a multi-stage stratified cluster sampling approach. The NFHS survey has a disproportionate number of women and men because it focuses primarily on women of reproductive age and children under five. As a result, the state module covered more women than men. The survey collects data on emanating issues related to health and family, which are provided by the successive NFHS rounds. NFHS data support the already running national programs through robust evidence, useful for monitoring and evaluation, and pave the way by identifying newer unmet needs of the population. The data were collected by using four types of questionnaires (Household, Woman's,

Man's, and Biomarker) and were translated into local languages using computer-assisted personal interviewing. In the Household Schedule, information was collected on all usual members of the household and visitors who stayed in the household the previous night, as well as socioeconomic characteristics of the household; water, sanitation, and hygiene; health insurance coverage; disabilities; land ownership; the number of deaths in the household in the 3 years preceding the survey; and the ownership and use of mosquito nets. The Woman's Schedule covered a wide variety of topics, including the woman's characteristics, marriage, fertility, contraception, children's immunizations and healthcare, nutrition, reproductive health, sexual behavior, HIV/AIDS, women's empowerment, and domestic violence. The Man's Schedule covered the man's characteristics, marriage, his number of children, contraception, fertility preferences, nutrition, sexual behavior, health issues, attitudes towards gender roles, and HIV/AIDS. The Biomarker Questionnaire of NFHS-4 covered measurements of height, weight, and hemoglobin for children, and measurements of height, weight, hemoglobin, blood pressure, and random blood glucose for women aged 15–49 and (in the state module subsample of households only) men aged 15–54. In addition to these, NFHS-5 also collected data regarding waist and hip circumference [12, 13].

Sample Selection

NFHS Round 4 covered 601,509 households, with 699,689 women (aged 15–49) and 112,122 men (aged 15–54), whereas NFHS round 5 covered 636,699 households, with 724,115 women (aged 15–49) and 101,839 men (aged 15–54). We excluded pregnant women from both rounds and men aged more than 49 years (to ensure comparability) for analyzing overweight/obesity among adults aged 15–49 years. Lastly, after adjusting for the missing values for various background characteristics and the information on the outcome variable, the final sample includes 558,122 women and 84,477 men from round 4, and 574,099 women and 74,761 men from round 5.

Ethical Approval

The data source for the study was national surveys conducted by the Government of India, and the anonymized dataset is freely available in the public domain. The institutional ethics committee of AIIMS Bathinda waived the need for ethical approval.

Study Variables

The presence of overweight and obesity was our primary dependent variable estimated using the BMI due to its interpretability and usage as a measure of the degree of adiposity in an individual. The BMI was calculated as the ratio of weight (in Kg) and height squared (in m) and expressed as kg/m^2. In the NFHS surveys, the weight of the respondents was measured using the Seca 874 digital scale, and height was measured using the Seca 213 stadiometer. The survey staff were rigorously trained to measure the anthropometric parameters accurately. The BMI estimates were further categorized as underweight, normal, overweight, and obese, as per the cut-offs for Asian people, i.e., 23–24.99 kg/m^2 for overweight and ≥ 25 kg/m^2 for obesity [14]. The above-mentioned are better, as Asian people have higher cardiovascular risks at a lower BMI [15]. The BMI was further categorized dichotomously for our analysis: "0" as "Underweight/Normal" (BMI < 23.00 kg/m^2) and "1" as "overweight/obese" (BMI ≥ 23.00 kg/m^2) [6].

Explanatory Variables

The explanatory variables include age (continuous), gender (men, women), marital status (categorized as currently married and not currently married), educational level (categorized as no education, primary education, and secondary or higher), place of residence (rural and urban), religion (categorized as Hindu, Muslim, and Other), caste groups (categorized as Scheduled Caste/Tribes, other backward classes, and others), tobacco and alcohol consumption

(both categorized as yes or no), access to clean cooking fuel (categorized as clean and unclean), access to clean drinking water (categorized as yes and no), and access to improved toilet facility (categorized as improved and not improved). Improved toilet facilities include any non-shared toilet types (flush/pour flush toilets to piped sewer systems, septic tanks, pit latrines, or an unknown destination; ventilated improved pit/biogas latrines; pit latrines with slabs; and twin pit/composting toilets) [16]. The wealth index is a composite measure of a household's cumulative living standard and is calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles, materials used for housing construction, and types of water access and sanitation facilities. The index was categorized as poorest, poor, middle, rich, and richest [17]. The NFHS also collects information on the frequency of consuming food items, such as milk/curd, pulses/beans, dark leafy vegetables, fruits, eggs, fish, chicken/meat, fried food, and aerated drinks. All these nine food items measure the same concept. Existing literature suggests that using multiple correspondence analysis can reduce the dimension; hence, the diet index was computed [18]. Further, the score generated was categorized to form a type of diet variable: healthy/normal or unhealthy. Lastly, diabetes was categorized as *yes* or *no* based on the random blood level ≥ 140 mg/dl.

Data Analysis

Firstly, bivariate analysis was used to ascertain the prevalence (with a 95% confidence interval) of overweight/obesity by different background characteristics across the two surveys separately for men and women. Appropriate weights were used while analyzing the prevalence provided by the NFHS survey. Further, the adjusted odds ratios were computed for both rounds to ascertain the potential predictors of overweight/obesity among individuals aged 18–49.

Lastly, multivariate decomposition analysis for non-linear response models was used to address the contributing factors to the change in the prevalence of obesity over two time points, i.e., from NFHS-4 (2015–2016) to NFHS-5 (2019–2021) [11]. This approach uses the output from logit regression models for ascertaining and partitioning the changeover given time points into two components [19]. The mean difference in overweight/obesity prevalence over the two surveys denoted by A (NFHS-5) and B (NFHS-4) can be decomposed as follows [11]:

$$\bar{Y}_A - \bar{Y}_B = \overline{F(X_B\beta_A)} - \overline{F(X_B\beta_B)}$$
$$= \underbrace{\left\{\overline{F(X_A\beta_A)} - \overline{F(X_B\beta_A)}\right\}}_{E} + \underbrace{\left\{\overline{F(X_B\beta_A)} - \overline{F(X_B\beta_B)}\right\}}_{C}$$

The first part (labeled as E) refers to the differential attributable to differences in endowments (characteristics of the respondents), i.e., the explained component. The second component ©) refers to the differential attributable to the difference in coefficients (changing effects of the variables), i.e., the unexplained component. Therefore, through this approach, the observed difference in the proportion of obesity between NFHS-4 and NFHS-5 will be additively decomposed into E and C.

For the current study, NFHS-5 was chosen as the reference group. Therefore, E reflects a counterfactual comparison of the differences in the outcome from the NFHS-5 perspective (i.e., the expected difference in obesity prevalence between the two time points if NFHS-5 were given NFHS-4 distribution of covariates). In contrast, the term C reflects a counterfactual comparison of the outcome from the NFHS-4 perspective (i.e., the expected difference if NFHS-4 would have the coefficients of NFHS-5). Therefore, to decompose the observed change in obesity prevalence among the study population, a logit model with a set of predictors, including individual, behavioral, and socio-demographic attributes, was used. Further, the *mvdcmp* package of STATA software version 16.0 was used to carry out the multivariate decomposition analysis, which facilitated the detailed composition and standard errors for the characteristic's component (i.e., change in the endowment over time) and the coefficient

component (i.e., change in the effect of predictors) [11].

RESULTS

As per NFHS 5, the mean age (SD) of the male and female participants was around 32.24 ± 9.03 and 32.36 ± 9.11 years. Table 1 depicts the basic socio-demographic profile of the participants included in the fourth and fifth rounds of the NFHS. Most of the NFHS 5 participants were from rural areas, following Hinduism, from other backward social castes, with education at least till secondary school or above, and currently married. A higher proportion used unclean fuels but had access to improved toilet facilities and drinking water. Around 43% and 35% of males consumed tobacco or alcohol, and over half of the participants had an unhealthy diet.

The overall weighted prevalence of overweight and obesity in the male and female study participants as per NFHS 5, was 44.02% and 41.16%, respectively, compared to 37.71% and 36.14% in NFHS 4, depicting a percentage relative increase of 16.7% and 13.8% (Table 2). The prevalence increased with age, urban residence, other religions, other or non-reserved social castes, with more years of education, and wealth status, currently married, having access to clean fuel, improved toilets, anddrinking water. The prevalence was higher in non-tobacco users, non-alcoholics, having a healthy diet, and people living with diabetes. Figure 1 further depicts the prevalence of overweight and obesity in different states of India. We subsequently explored the predictors of overweight and obesity in the study participants using the multivariable binary logistic regression approach and appending the male and female datasets of the two rounds (Table 3). In NFHS 5, the adjusted odds (aOR) of living overweight or with obesity increased with age was higher in males from urban areas, following other religions, having more years of education, belonging to other social castes, richest quintiles, and currently married. The aOR was also significantly higher for those with clean fuel and toilets. Tobacco consumption was associated with lesser odds, but higher odds were seen with alcohol consumption patterns and in people living with diabetes.

Results from the decomposition analyses (Tables 4 and 5) depict that the proportion of obesity increased by 6.37% and 5.10% points among men and women (aged 18–49 years), respectively, from NFHS-4 to 5. Further, the endowment is accounted for by the change in the composition of a variable, while the change in the effect of the variable accounts for the coefficient. Therefore, among men (Table 4), compositional differences accounted for 16.54%, and the difference in coefficient or effect accounted for 83.46% of the increase in the prevalence of overweight/obesity among the study sample from 2015–16 to 2019–21 survey datasets. The major increase in overweight/obesity between the two surveys due to compositional differences was due to differences in individuals' age, belonging to the better-off families, those who smoke, households using unclean cooking fuel, and the presence of diabetes. However, between the 2015–2016 and 2019–2021 surveys, among women, 49.90% of the differential in overweight/obesity prevalence was attributable to the compositional differences, while 50.10% of the differential was attributable to the differences in coefficients or effect. The significant increase in overweight/obesity among women aged 18–49 over the two surveys due to compositional differences was due to differences in age, education, wealth index, smoking status, households with unclean cooking fuel, unimproved toilet facilities, and the presence of diabetes.

DISCUSSION

Living with overweight or obesity has multiple implications for the person and for society at large [4]. The current study focuses on adults as they witness the rapid transition in their lifestyle, including work culture, substance abuse, decreased physical activity, and unhealthy eating habits. With the steady progress of adults to the geriatric age groups, we need to prepare ourselves for the impending consequences of this newer lifestyle in the form of increased

Table 1 Sample characteristics of the adults (women and men aged 18–49 years) by background characteristics in India using NFHS-4 (2015–2016) and NFHS-5 (2019–2021)

Continuous variables	Unweighted counts (weighted proportions)			
	NFHS-4 (2015–2016)		NFHS-5 (2019–2021)	
	Men	Women	Men	Women
Total	84,477 (100)	558,122 (100)	74,761 (100)	574,099 (100)
Age (in years) (mean (SD)	31.84 (9.02)	31.87 (9.03)	32.24 (9.03)	32.36 (9.11)
Place of residence				
Urban	26,717 (37.60)	165,710 (34.72)	19,050 (34.21)	141,895 (32.17)
Rural	57,760 (62.40)	392,412 (65.28)	55,711 (65.79)	432,204 (67.83)
Religion				
Hindu	65,417 (83.68)	426,666 (82.55)	57,974 (82.70)	445,820 (83.94)
Muslim	8877 (10.88)	60,013 (11.56)	7269 (12.06)	56,760 (10.86)
Others	10,183 (5.44)	71,443 (5.88)	9518 (5.24)	71,519 (5.20)
Social group				
Others	18,014 (24.29)	122,177 (24.32)	14,659 (22.67)	115,166 (22.28)
Other backward castes	34,610 (45.65)	226,983 (45.05)	29,988 (44.94)	229,640 (44.92)
Scheduled castes /scheduled tribe	31,853 (30.06)	208,962 (30.64)	30,114 (32.39)	229,293 (32.80)
Level of education				
No education	11,147 (12.85)	174,320 (30.65)	8594 (11.46)	149,380 (25.44)
Primary	11,181 (12.80)	75,086 (13.26)	8675 (12.08)	72,465 (12.63)
Secondary and above	62,149 (74.35)	308,716 (56.10)	57,492 (76.49)	352,254(61.93)
Wealth index				
Richest	17,260 (22.99)	108,712 (21.51)	12,664 (19.66)	98,649 (20.21)
Rich	17,515 (22.34)	111,946 (21.48)	15,030 (22.83)	112,705 (21.28)
Middle	18,255 (21.35)	116,453 (20.57)	16,161 (21.93)	121,851 (20.96)
Poor	17,268 (18.60)	116,308 (19.18)	16,546 (19.36)	125,631 (19.79)
Poorest	14,179 (14.71)	104,703 (17.26)	14,360 (16.22)	115,263 (17.75)
Marital status				
Not currently married	27,151 (31.77)	118,712 (19.83)	24,742 (32.91)	127,910 (20.93)
Currently married	57,326 (68.23)	439,410 (80.17)	50,019 (67.09)	446,189 (79.07)
Access to clean cooking fuel				
Clean	33,265 (46.32)	206,224 (42.70)	39,391 (62.22)	295,051 (43.24)
Unclean	51,212 (53.68)	351,898 (57.30)	35,370 (37.78)	279,048 (56.76)

Table 1 continued

Continuous variables	Unweighted counts (weighted proportions)			
	NFHS-4 (2015–2016)		NFHS-5 (2019–2021)	
	Men	Women	Men	Women
Access to toilet facility				
Improved	50,168 (61.02)	331,023 (60.01)	59,196 (79.10)	456,028 (78.93)
Unimproved	34,309 (38.98)	227,099 (39.99)	15,565 (20.90)	118,070 (21.07)
Access to drinking water				
Improved	75,951 (90.52)	485,028 (87.50)	67,472 (90.49)	507,799 (88.66)
Unimproved	8526 (9.48)	73,094 (12.50)	7189 (9.51)	66,300 (11.34)
Tobacco				
No	40,026 (51.35)	492,946 (92.34)	40,073 (56.81)	572,923 (99.90)
Yes	44,451 (48.65)	65,176 (7.66)	34,688 (43.19)	1176 (0.10)
Alcohol				
No	54,588 (67.13)	542,451 (98.62)	53,143 (74.31)	561,696 (99.14)
Yes	29,889 (32.87)	15,671 (1.38)	21,618 (25.69)	12,403 (0.86)
Diet				
Normal/healthy	42,776 (47.58)	274,844 (50.17)	37,569 (43.59)	279,698 (48.44)
Unhealthy	41,701 (52.42)	283,278 (49.83)	37,192 (56.41)	294,401 (51.56)
Diabetes				
No	75,858 (89.34)	519,216 (92.61)	65,554 (86.16)	517,385 (89.14)
Yes	8619 (10.66)	38,906 (7.39)	9207 (13.84)	56,714 (10.86)

NFHS National Family Health Survey

morbidity due to NCDs [20]. Our study depicts specific findings that cause concern. First, the overall multivariate decomposition analysis (2015–2016 and 2019–2021) revealed that about 90% and 60% of the overall increase in overweight/obesity among men and women, respectively, was due to the difference in coefficient (difference in the effect of characteristics) across the surveys, whereas the remaining was due to the difference in composition of the respondent (endowment) across the surveys. Second, there has been a surge in the prevalence of overweight and obesity in a very short time (approximately 5 years) between the two study rounds. Thirdly, specific socio-demographic characteristics explained overweight and obesity with significantly higher odd ratios.

The analysis revealed that the contribution of coefficients was more critical than that of the characteristic changes to the increase in prevalence. After controlling the role of changes due to coefficients, only 16.5% and 50% of the increased prevalence were attributed to changes in the composition of the respondents (i.e., the endowments), age, wealth index, tobacco use, access to clean fuel, and unhealthy diet emerged as significant factors in men, in addition to better education among women. Further, about 90% and 60% increases were attributed to these changes only. A previous

Table 2 Weighted prevalence of overweight/obesity among adults (women and men aged 18–49 years) by background characteristics in India using NFHS-4 (2015–2016) and NFHS-5 (2019–2021)

	NFHS-4 (2015–2016)		NFHS-5 (2019–2021)	
	Men Weighted prevalence (95% CIs)	Women Weighted prevalence (95% CIs)	Men Weighted prevalence (95% CIs)	Women Weighted prevalence (95% CIs)
Total	37.71 (37.38, 38.03)	36.14 (36.01, 36.26)	44.02 (43.65, 44.38)	41.16 (41.03, 41.29)
BMI (mean (SD)	22.05 (3.83)	21.99 (4.29)	22.77 (4.12)	22.61 (4.48)
Age (in years)				
15–19	13.16 (12.38, 13.97)	11.70 (11.40, 12.01)	16.73 (15.77, 17.73)	13.46 (13.14, 13.79)
20–24	24.35 (23.68, 25.04)	19.73 (19.49, 19.98)	28.03 (27.24, 28.84)	23.17 (22.91, 23.44)
25–29	36.45 (35.68, 37.23)	31.64 (31.35, 31.93)	42.55 (41.67, 43.43)	36.26 (35.96, 36.56)
30–34	43.37 (42.54, 44.21)	40.72 (40.39, 41.04)	50.31 (49.39, 51.23)	46.53 (46.21, 46.86)
35–39	46.62 (45.75, 47.49)	45.50 (45.17, 45.84)	52.96 (52.04, 53.87)	50.99 (50.66, 51.32)
40–44	47.62 (46.69, 48.55)	49.24 (48.87, 49.60)	53.71 (52.70, 54.73)	54.43 (54.07, 54.78)
45–49	46.62 (45.67, 47.57)	50.77 (50.40, 51.14)	54.38 (53.39, 55.37)	55.05 (54.70, 55.39)
Place of residence				
Urban	48.73 (48.18, 49.28)	49.67 (49.45, 49.89)	52.09 (51.46, 52.72)	52.25 (52.02, 52.48)
Rural	31.07 (30.67, 31.46)	28.94 (28.79, 29.08)	39.82 (39.38, 40.26)	35.90 (35.75, 36.05)
Religion				
Hindu	36.76 (36.40, 37.11)	34.99 (34.86, 35.13)	43.24 (42.84, 43.64)	40.10 (39.96, 40.24)
Muslim	40.18 (39.18, 41.18)	40.16 (39.78, 40.54)	46.16 (45.11, 47.22)	45.51 (45.12, 45.9)
Others	47.39 (45.95, 48.84)	44.25 (43.72, 44.79)	51.35 (49.74, 52.95)	49.09 (48.52, 49.66)
Social group				
Others	46.24 (45.56, 46.92)	44.63 (44.36, 44.89)	50.35 (49.58, 51.12)	49.3 (49.02, 49.57)
Other backward castes	38.28 (37.80, 38.77)	36.60 (36.41, 36.79)	45.04 (44.50, 45.59)	41.81 (41.62, 42.00)
Scheduled castes/ scheduled tribe	29.94 (29.38, 30.50)	28.71 (28.50, 28.92)	38.15 (37.53, 38.78)	34.74 (34.52, 34.96)
Level of education				
No education	26.23 (25.41, 27.06)	29.28 (29.06, 29.49)	35.19 (34.16, 36.24)	36.79 (36.54, 37.03)
Primary	31.98 (31.11, 32.86)	36.19 (35.85, 36.54)	38.17 (37.14, 39.2)	42.53 (42.17, 42.9)
Secondary and above	40.68 (40.29, 41.06)	39.87 (39.70, 40.04)	46.26 (45.84, 46.68)	42.67 (42.51, 42.84)
Wealth index				
Richest	57.38 (56.68, 58.07)	55.58 (55.30, 55.86)	59.99 (59.18, 60.80)	57.91 (57.63, 58.20)
Rich	46.28 (45.57, 46.99)	46 (45.71, 46.28)	52.79 (52.03, 53.56)	49.23 (48.95, 49.51)

Table 2 continued

	NFHS-4 (2015–2016)		NFHS-5 (2019–2021)	
	Men Weighted prevalence (95% CIs)	Women Weighted prevalence (95% CIs)	Men Weighted prevalence (95% CIs)	Women Weighted prevalence (95% CIs)
Middle	35.19 (34.49, 35.88)	34.65 (34.37, 34.92)	43.21 (42.43, 43.99)	41.21 (40.93, 41.49)
Poor	23.56 (22.91, 24.23)	24.16 (23.91, 24.42)	33.65 (32.87, 34.44)	32.04 (31.77, 32.31)
Poorest	15.50 (14.87, 16.14)	14.72 (14.50, 14.95)	25.76 (24.97, 26.56)	22.51 (22.26, 22.77)
Marital status				
Currently unmarried	26.13 (25.60, 26.65)	23.32(23.08, 23.57)	31.67 (31.08, 32.27)	26.51 (26.26, 26.76)
Currently married	43.10 (42.70, 43.50)	39.30 (39.16, 39.45)	50.07 (49.62, 50.52)	45.04 (44.89, 45.18)
Access to clean cooking fuel				
Clean	50.55 (50.05, 51.04)	50.31 (50.11, 50.51)	50.61 (50.15, 51.08)	49.5 (49.33, 49.68)
Unclean	26.63 (26.23, 27.04)	25.57 (25.42, 25.72)	33.15 (32.59, 33.72)	30.2 (30.02, 30.39)
Access to toilet facility				
Improved	45.89 (45.46, 46.32)	44.79 (44.62, 44.95)	47.35 (46.94, 47.76)	44.5 (44.36, 44.65)
Unimproved	24.9 (24.44, 25.37)	23.15 (22.98,23.33)	31.39 (30.65, 32.14)	28.62 (28.36, 28.88)
Access to drinking water				
Improved	37.76 (37.41, 38.10)	36.31 (36.17, 36.44)	43.72 (43.34, 44.10)	41.4 (41.02, 41.78)
Unimproved	37.23 (36.18, 38.30)	34.95 (34.59, 35.3)	46.82 (45.63, 48.00)	41.13 (40.99, 41.26)
Smoke				
No	42.21 (41.75, 42.68)	36.96 (36.83, 37.09)	47.17 (46.69, 47.66)	41.16 (41.04, 41.29)
Yes	32.95 (32.50, 33.41)	26.23 (25.81, 26.65)	39.86 (39.31, 40.41)	35.96 (32.15, 39.95)
Alcohol consumption				
No	37.29 (36.90, 37.69)	36.27 (36.14, 36.39)	43.64 (43.22, 44.07)	41.24 (41.11, 41.37)
Yes	38.55 (37.98, 39.12)	26.63 (25.65, 27.62)	45.09 (44.37, 45.81)	32.03 (30.74, 33.36)
Diet				
Normal/healthy	34.24 (33.78, 34.71)	37.17 (36.99, 37.35)	42.32 (41.77, 42.87)	42.16 (41.98, 42.35)
Unhealthy	40.85 (40.40, 41.31)	35.09 (34.92, 35.27)	45.33 (44.84, 45.81)	40.22 (40.04, 40.39)
Diabetes				
No	35.91 (35.57, 36.26)	34.55 (34.42, 34.68)	41.42 (41.03, 41.81)	38.91 (38.78, 39.05)
Yes	52.72 (51.69, 53.75)	56.05 (55.57, 56.53)	60.15 (59.18, 61.11)	59.60 (59.21, 59.98)

NFHS National Family Health Survey, *BMI* body mass index

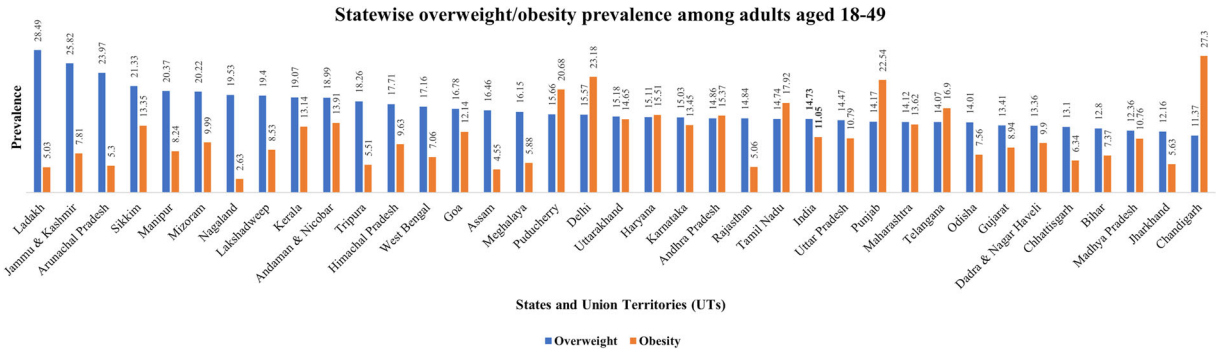

Fig. 1 State-wise prevalence of overweight and obesity among adult participants (18–49 years) of the National Family Health Survey-5 (2019–2021)

study from Ethiopia conducted only among women attributed about 39% to the compositional differences [21]. Major contributing variables included age, urban residence, wealth index, access to clean fuel, toilet facilities, and unhealthy diet.

While higher age groups depicted the highest odds of being overweight or obese, we observed that younger age groups in men contributed more to the incremental increase and were in contrast to findings observed in women. Bad eating habits in childhood result in overweight adults [22]. When kids are fed more than necessary, they adapt to high quantities over a period [23]. Further, the escalation can be attributed to an increased sedentary lifestyle among the younger generation. Also, the fifth round was conducted between 2019 and 2021, which witnessed the COVID-19 pandemic attributed to restrictions in mobility and the adoption of work-from-home culture, and can be seen as a strong reason for increased body weight [24]. Specifically in women, 25–49 years is a reproductive peak age characterized by related changes in body composition, which entails a higher probability of overweight/obesity [25]. Women of childbearing age are usually fed well and have reduced mobility while nursing a child. This also concurs with the findings from other countries [26]. While our female participants were from reproductive age groups, it is possible to observe an increment in older age, as fat is gradually redistributed to the abdominal cavity with health implications in such women [27]. While our results are similar to a study done in Brazil [28], we also have contrasting results. The overall difference might be in the study population, where, in some countries, better-educated women are engaged more in white-collar jobs and have increased sedentary lifestyles [29, 30].

Residence in the urban areas depicted higher odds and contributed more to the increase in the prevalence than in rural areas in both males and females. Current evidence suggests that people have a similar inclination towards fatty food and processed food in both urban and rural areas [22]. However, inclination in urban areas is supported by the easy availability of processed and junk food, better noticeability of advertisements through multi-media channels that promote fatty and processed food, and the brand-building strategy of the big business houses that target young consumers, addiction to these ultra-processed foods because they please the taste buds [31]. Moreover, congested urban areas have poor walkability index, further impacting physical activity levels [32]. Fewer years of education maximally contributed to prevalence in men but not in women. Less education is related to low-income jobs, and most such people tend to rely on low-cost junk foods that are rich in calories without knowing their long-term adverse effects on health, including BMI. Further, such people are engaged chiefly in work-related physical activity, which offers no protective effect against obesity and is deleterious to health. However, in women, better education was related to protecting against obesity as they became better

Table 3 Adjusted odds ratios (aOR) of overweight/obesity among adults (women and men aged 18–49 years) by background characteristics, India, 2015–2016, 2019–2021

	NFHS-4 (2015–2016) aOR (95% CIs)	NFHS-5 (2019–2021) aOR (95% CIs)
Age (years)		
15–19	Ref. value	Ref. value
20–24	1.68 (1.63, 1.74)***	1.71 (1.67, 1.76)***
25–29	3.07 (2.98, 3.17)***	3.03 (2.94, 3.13)***
30–34	4.77 (4.62, 4.93)***	4.64 (4.50, 4.79)***
35–39	5.97 (5.77, 6.17)***	5.66 (5.49, 5.84)***
40–44	7.01 (6.78, 7.25)***	6.41 (6.21, 6.61)***
45–49	7.51 (7.27, 7.78)***	6.64 (6.43, 6.85)***
Gender		
Women	Ref. value	Ref. value
Men	1.13 (1.11, 1.15)***	1.24 (1.21, 1.26)***
Place of residence		
Rural	Ref. value	Ref. value
Urban	1.24 (1.22, 1, 25)***	1.13 (1.11, 1.14)***
Religion		
Hindu	Ref. value	Ref. value
Muslim	0.85 (0.83, 0.87)***	1.26 (1.24, 1.28)***
Others	1.09 (1.06, 1.12)***	1.22 (1.19, 1.25)***
Level of education		
No education	Ref. value	Ref. value
Primary	1.24 (1.22, 1.26)***	1.22 (1.24, 1.28)***
Secondary and above	1.38 (1.36, 1.40)***	1.39 (1.37, 1.41)***
Wealth index		
Richest	Ref. value	Ref. value
Rich	0.78 (0.77, 0.79)***	0.77 (0.76, 0.79)***
Middle	0.60 (0.59, 0.61)***	0.61 (0.60, 0.63)***
Poor	0.42 (0.41, 0.43)***	0.46 (0.45, 0.47)***
Poorest	0.25 (0.24, 0.26)***	0.32 (0.31, 0.33)***
Marital status		
Currently unmarried	Ref. value	Ref. value
Currently married	1.38 (1.36, 1.41)***	1.37 (1.35, 1.39)***

Table 3 continued

	NFHS-4 (2015–2016) aOR (95% CIs)	NFHS-5 (2019–2021) aOR (95% CIs)
Access to clean cooking fuel		
Clean	Ref. value	Ref. value
Unclean	0.79 (0.77, 0.80)***	0.85 (0.84, 0.86)***
Access to toilet facility		
Improved	Ref. value	Ref. value
Unimproved	0.87 (0.86, 0.88)***	0.89 (0.88, 0.90)***
Access to drinking water		
Improved	Ref. value	Ref. value
Unimproved	1.06 (1.04, 1.08)***	1.08 (1.06, 1.10)***
Smoke		
No	Ref. value	Ref. value
Yes	0.69 (0.67, 0.70)***	0.72 (0.70, 0.74)***
Alcohol consumption		
No	Ref. value	Ref. value
Yes	1.08 (1.05, 1.11)***	1.03 (1.00, 1.07)
Diet		
Normal/healthy	Ref. value	Ref. value
Unhealthy	0.91 (0.90, 0.92)***	0.92 (0.91, 0.93)***
Diabetes		
No	Ref. value	Ref. value
Yes	1.71 (1.68, 1.75)***	1.75 (1.72, 1.78)***

***Statistically significant $p < 0.001$

aware [33]. With education, women become more empowered and step out of their homes, leading to increased physical activity, and are thus benefitted [34]. Further, richer participants had higher odds of being overweight or obese and contributed maximally to the incremental increase compared to the poorer group of the survey participants. With more wealth, people tend to have more helping hands and primarily work in managerial positions, having a predominantly sedentary lifestyle [35]. Moreover, most of their everyday needs are taken care of by technology, like escalators, with people avoiding the stairs, washing machines and dishwashers, which diminish the calorie consumption worsened by increased calorie intake.

Married participants depicted significantly higher odds of being overweight or obese, but inconsistently contributed to the incremental increase. Married status leads to a stable lifestyle, which leads couples in a union tending to eat as per the preference of their mates, thus pointing towards the communicable nature of the behavioral factors. On the other hand, unmarried people tend to engage in a more casual lifestyle by consuming more junk

Table 4 Multivariate decomposition results of overweight/obesity based on men aged 18–49 years, India, 2019–2021 and 2015–2016

	NFHS-5 (2019–2021)–NFHS-4 (2015–2016)			
	Due to the difference in the composition of the respondent (endowment)		Due to differences in coefficient (difference in the effect of characteristics)	
	Coefficient (%) (95% CI)	Percent	Coefficient (%) (95% CI)	Percent
Age (in years)				
15–19	Ref. value		Ref. value	
20–24	– 0.13 (– 0.14, – 0.12)***	2.02	– 0.04 (– 0.37, 0.29)	0.68
25–29	– 0.13 (– 0.15, – 0.12)***	2.08	0.44 (– 0.09, 0.98)	– 6.95
30–34	– 0.04 (– 0.05, – 0.03)***	0.61	– 0.03 (– 0.48, 0.42)	0.46
35–39	0 (0, 0)**	0.04	0 (– 0.39, 0.4)	– 0.05
40–44	0 (– 0.02, 0.01)	0.06	0.12 (– 0.26, 0.51)	– 1.94
45–49	0 (0, 0)	– 0.01	0.12 (– 0.21, 0.45)	– 1.95
Place of residence				
Rural	Ref. value		Ref. value	
Urban	0.07 (0.04, 0.11)***	– 1.16	0.78 (0.16, 1.4)**	– 12.27
Religion				
Hindu	Ref. value		Ref. value	
Muslim	– 0.06 (– 0.09, – 0.03)***	0.89	0.05 (– 0.28, 0.37)	– 0.73
Others	0 (0, 0)***	– 0.02	0 (– 0.15, 0.15)	– 0.03
Level of education				
No education	Ref. value		Ref. value	
Primary	0.02 (0.01, 0.02)***	– 0.24	0.17 (– 0.17, 0.51)	– 2.6
Secondary and above	0.12 (– 0.15, – 0.09)***	1.87	– 0.39 (– 2.15, 1.37)	6.09
Wealth Index				
Richest	Ref. value		Ref. value	
Rich	0.93 (0.86, 1.01)***	– 14.66	1.7 (1.03, 2.37)***	– 26.67
Middle	– 0.02 (– 0.02, – 0.01)***	0.24	1.41 (0.76, 2.06)***	– 22.15
Poor	0 (0, 0)***	0.03	1.3 (0.77, 1.84)***	– 20.47
Poorest	– 0.09 (– 0.11, – 0.07)***	1.41	0.69** (0.23, 1.15)	– 10.79
Marital status				
Currently unmarried	Ref. value		Ref. value	
Currently Married	0.07 (0.06, 0.09)***	– 1.14	– 0.64 (– 1.35, 0.06)	10.1

Table 4 continued

	NFHS-5 (2019–2021)–NFHS-4 (2015–2016)			
	Due to the difference in the composition of the respondent (endowment)		Due to differences in coefficient (difference in the effect of characteristics)	
	Coefficient (%) (95% CI)	Percent	Coefficient (%) (95% CI)	Percent
Smoke				
No	Ref. value		Ref. value	
Yes	− 0.36 (− 0.41, − 0.31)***	5.65	− 0.48 (− 1.14, 0.17)	7.56
Alcohol consumption				
No	Ref. value		Ref. value	
Yes	0.14 (0.06, 0.22)***	− 2.19	0.03 (− 0.39, 0.45)	− 0.48
Access to clean cooking fuel				
Clean	Ref. value		Ref. value	
Unclean	0.48 (0.66, 0.29)***	7.48	− 0.47 (− 1.13, 0.19)	7.44
Access to toilet facility				
Improved	Ref. value		Ref. value	
Unimproved	0.21 (− 0.42, − 0.01)	3.24	0.21 (− 0.17, 0.59)	− 3.34
Access to drinking water				
Improved	Ref. value		Ref. value	
Unimproved	0.00 (− 0.00, − 0.00)	0.00	− 0.06 (− 0.27, 0.16)	0.89
Diet				
Normal/healthy	Ref. value		Ref. value	
Unhealthy	− 0.17 (0.22, 0.13)***	2.70	1.02 (0.20, 1.84)**	− 15.99
Diabetes				
No	Ref. value		Ref. value	
Yes	− 0.49 (− 0.58, − 0.40)***	7.62	− 0.46 (− 0.88, − 0.03)*	7.15
Intercept			− 10.80 (− 14.64, − 6.91)***	169.52
Total	− 1.05 (− 1.41, − 0.70)***	16.54	− 5.32 (− 6.17, − 4.46)***	83.46
Total increase	− 6.37 (− 7.13, − 5.62)***			

NFHS National Family Health Survey, *BMI* body mass index
Statistically significant *$p < 0.05$
**$p < 0.01$
***$p < 0.001$

Table 5 Multivariate decomposition results of overweight/obesity based on women aged 18–49 years, India, 2019–2021 and 2015–2016

Continuous variables	NFHS-5 (2019–2021)–NFHS-4 (2015–2016)			
	Due to differences in characteristics		Due to differences in coefficient	
	Due to the difference in the composition of the respondent (endowment)		Due to differences in coefficient (difference in the effect of characteristics)	
	Coefficient (%) (95% CI)	Percent	Coefficient (%) (95% CI)	Percent
Age (in years)				
15–19	Ref. value		Ref. value	
20–24	− 0.08 (− 0.09, − 0.08)***	1.66	− 0.17 (− 0.27, − 0.08)***	3.41
25–29	− 0.31 (− 0.32, − 0.30)***	6.08	− 0.54 (− 0.68, − 0.4)***	10.57
30–34	− 0.06 (− 0.06, − 0.05)***	1.08	− 0.41 (− 0.54, − 0.27)***	8.00
35–39	− 0.01 (− 0.01, − 0.01)***	0.23	− 0.31 (− 0.43, − 0.2)***	6.16
40–44	0.02 (0.02, 0.03)***	− 0.43	− 0.24 (− 0.36, − 0.13)***	4.79
45–49	0.00 (0.00, 0.00)***	− 0.02	− 0.11 (− 0.21, − 0.01)***	2.13
Place of residence				
Rural	Ref. value		Ref. value	
Urban	0.09 (0.08, 0.1)***	− 1.84	0.52 (0.34, 0.69)***	− 10.08
Religion				
Hindu	Ref. value		Ref. value	
Muslim	0.01 (0.01, 0.01)***	− 0.25	0.03 (− 0.05, 0.12)	− 0.67
Others	0.02 (0.01, 0.02)***	− 0.29	− 0.04 (− 0.09, 0.01)	0.78
Level of education				
No education	Ref. value		Ref. value	
Primary	0.03 (0.02, 0.03)***	− 0.53	0.03 (− 0.05, 0.12)	− 0.62
Secondary and above	− 0.39 (− 0.42, − 0.36)***	7.62	0.03 (− 0.32, 0.38)	− 0.56
Wealth index				
Richest	Ref. value		Ref. value	
Rich	0.26 (0.25, 0.26)***	− 5.00	0.77 (0.56, 0.98)***	− 15.06
Middle	0.1 (0.1, 0.1)***	− 1.95	0.86 (0.67, 1.05)***	− 16.87
Poor	− 0.01 (− 0.01, − 0.01)***	0.14	0.69 (0.54, 0.85)***	− 13.57
Poorest	− 0.05 (− 0.06, − 0.05)***	1.05	0.46 (0.32, 0.59)***	− 8.95
Marital status				
Currently unmarried	Ref. value		Ref. value	
Currently married	0.08 (0.08, 0.09)***	− 1.61	− 0.05 (− 0.19, 0.08)*	1.07

Table 5 continued

Continuous variables	NFHS-5 (2019–2021)–NFHS-4 (2015–2016)			
	Due to differences in characteristics		Due to differences in coefficient	
	Due to the difference in the composition of the respondent (endowment)		Due to differences in coefficient (difference in the effect of characteristics)	
	Coefficient (%) (95% CI)	Percent	Coefficient (%) (95% CI)	Percent
Smoke				
No	Ref. value		Ref. value	
Yes	− 0.52 (− 0.57, − 0.47)***	10.23	− 0.01 (− 0.01, 0.00)**	0.11
Alcohol consumption				
No	Ref. value		Ref. value	
Yes	− 0.01 (− 0.02, 0)	0.14	0.01 (0.00, 0.03)	− 0.36
Access to clean cooking fuel				
Clean	Ref. value		Ref. value	
Unclean	− 0.66 (− 0.73, − 0.59)***	12.94	− 0.57 (− 0.80, − 0.34)***	11.15
Toilet facility				
Improved	Ref. value		Ref. value	
Unimproved	− 0.54 (− 0.63, − 0.45)***	10.62	− 0.12 (− 0.24, − 0.01)*	2.40
Drinking water				
Improved	Ref. value		Ref. value	
Unimproved	0.02 (0.01, 0.02)***	− 0.32	− 0.03 (− 0.10, 0.05)	0.56
Diet				
Normal/healthy	Ref. value		Ref. value	
Unhealthy	0.04 (0.04, 0.05)***	− 0.83	− 0.19 (− 0.41, 0.03)	3.70
Diabetes				
No	Ref. value		Ref. value	
Yes	− 0.57 (− 0.60, − 0.54)***	11.16	0.00 (− 0.11, 0.11)	− 0.04
Intercept			− 3.17 (− 4.23, − 2.11)***	62.07
Total	− 2.55 (− 2.68, − 2.41)***	49.90	− 2.56 (− 2.84, − 2.27)***	50.10
Total increase	− 5.10 (− 5.34, − 4.86)***			

NFHS National Family Health Survey, *BMI* body mass index
Statistically significant *$p < 0.05$
**$p < 0.01$
***$p < 0.001$

food and substance abuse, which tells us the other side of the story. Married people also have less time for physical activity since they have more family duties, and their commitment to maintaining a healthy weight may decrease [36, 37]. Although we observed higher odds of being overweight and obese in those with access to better toilets, drinking water, and cooking fuel, their contribution was nearly non-significant on decomposition analysis. A previous analysis among adolescent girls has depicted that access to better toilets and clean drinking water helped to increase weight, which may also be a plausible explanation for our population [38]. With the recent thrust of the Indian Government on the Swachha Bharat mission to improve the WASH (water, sanitation and hygiene) indicators, access to better toilets and clean drinking water has improved [39]. Better WASH indicators significantly affect childhood malnutrition, as seen in our previous analysis [40]. We observed the presence of diabetes as an important contributor to the increasing prevalence of obesity. Although the causal mechanism is difficult to understand using cross-sectional data, previous research points towards a bi-directional relationship between obesity and diabetes. However, in obesity, insulin sensitivity, as well as the modulation of β-cell function, decreases [41]. Further, abdominal fat, which is more common in the Indian population, is considered more lipolytic than subcutaneous fat, and does not respond easily to the antilipolytic action of insulin, which makes intra-abdominal fat more important in causing insulin resistance and, thus, diabetes [8, 42].

There are particular strengths and limitations of this study. To the best of our knowledge, the present study is among the first that identifies the trend contributions of factors to the change in overweight/obesity in India. Using nationally representative datasets collected using a robust methodology and analyzed using appropriate sampling weights makes the results generalizable. However, the secondary dataset suffers from their own set of limitations. Firstly, the cross-sectional nature of the data collection across different waves restricts us from making temporal associations. The surveys used only a restricted number of variables, which may not be able to comprehensively explain the development of overweight and obesity. There are many other significant factors, as per previous literature, like basal metabolic rates, physical activity levels, eating patterns, sleep, stress, genetic profiles, epigenetic modifications, and adverse effects of various drugs like oral contraceptives, that contribute to the development of overweight and obesity, but were beyond the scope of the present analysis [43]. Lastly, overweight and obesity in the elderly is a bigger problem, but such data were not collected by NFHS because of its different primary goals. Future research could be carried out to present a more comprehensive picture using the findings from these two surveys.

Specific policy implications and subsequent recommendations are emerging from our study. Such an incremental increase within a short duration is a cause for concern. It points towards an impending public health crisis due to emerging complications from overweight and obesity, like diabetes and cardiovascular diseases. The health system should prioritize health advocacy and target the population from childhood. Health awareness should target everyone uniformly as the problem is universal and not specific to any particular segment of society. The government should formulate better policies that help people engage more in physical activity and restrain junk foods, like open-air gyms and sugar taxes, that are effective in the long run [44].

In conclusion, we can say that the rate of overweight/obesity among adults in India has significantly increased over a very short period. Most of the overall change in overweight/obesity over the study period was attributable to the change in the coefficients of selected explanatory variables. The change in the socio-demographic characteristics has a significant impact on the change in overweight/obesity. The problem is no longer limited to rich and developed countries. Hence, program interventions should prioritize health advocacy programs and aggressively target behavioral modifications, while preparing the health systems to manage the people living with obesity

through the tertiary level of a prevention approach to a lighter nation in the future.

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Data Availability. This study analyses a nationally representative survey database available freely in the public domain (https://dhsprogram.com/data/available-datasets.cfm) and can be accessed using standard protocols.

Declarations

Conflict of interest. Madhur Verma, Vandana Esht, Mohammed M Alshehri, Mohammed Aljahni, Kirti Chauhan, Walaa E Morsy, Nitin Kapoor and Sanjay Kalra have no conflicts of interest to disclose.

Ethical Approval. The data source for the study was national surveys conducted by the Government of India, and the anonymized dataset is freely available in the public domain. The institutional ethics committee of AIIMS Bathinda waived the need for ethical approval.

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