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Correlation Between Mean Body Mass Index in The Population and Prevalence of Obesity in The Adult Male Population (20-54 Years) Living in Indian Sates: Empirical Evidence for a Population Based Approach of Obesity

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Introduction - Obesity has become a major public health problem both in developed and developing countries (1). Overweight and obesity are the fifth leading risk for global deaths (2). At least 2.8 million adults die each year as a result of being overweight and obese (3). Currently, a simple anthropometric measurement, the body mass index (BMI), is widely used to diagnose obesity. However, BMI can be affected by many factors such as race and socioeconomic factors, which makes formulating a unified diagnostic criterion difficult.

Many research studies are carried out on evaluation of under nutrition among Indian men (4) and women (5,6). Some research studies are also carried out on evaluation of overweight and obesity among Indian women (7,8) and among 36 low to medium countries (9).

Patil and Shinde (2014) studied zonal and state-wise prevalence and risk factors of undernutrition among Indian men in the age-group of 15 to 54 years based on sampled data of 74,369 respondents from the 3rd National Family Health Survey (NFHS-3). Patil and Shinde reported that among Indian men,overall 28.6% Indian men are classified as underweight (BMI< 18.5 kg/m2) and 52.5% younger (15-19 years) are underweight. Highest prevalence of underweight men in Indian states is observed in Tripura followed by Rajasthan, Chhattisgarh and Gujarat. Patil and Shinde concluded that the distribution of underweight in India remains segregated by socio-economic status.

Chockalingam et al (2011) analyzed a sample of 118,734 women from India based on NFHS-3, with multiple categories on BMI (underweight, normal weight, overweight, obese). Chockalingam et al (2011) reported that the female respondents, who are married, employed and having higher level of education had a lower prevalence of undernutrition. Sengupta and Syamala (2012) studied the changing face of malnutrition in India by analyzing the 2nd National Family Health Survey (NFHS-2) and NFHS-3 data to assess the levels and trends of malnutrition among women (both underweight as well as overweight) in India and its states. Sengupta and Syamala reported that underweight (BMI< 18.5 kg/m2) in India was a problem that cuts across all social and economic categories; where as being overweight or obese was a problem of the wealthier, urban women. Sengupta et al. (2014) studied the gravity of the double burden of malnutrition among 21 states of India, through a comparative analysis of traditional and Asian population-specific BMI categorizations for overweight (BMI ranging between 23 to 27.4 kg/m2) and obesity (BMI ? 27.5 kg/m2) among women by analyzing the NFHS-2 and NFHS-3 data. Sengupta et al. reported that with Asian population-specific cutoffs, 11 states can be classified as double burden states; however, following traditional categorization, only 4 states face such dual pressure.

Mamun and Finlay (2015) studied the shift from undernutrition (BMI<18.5) towards over nutrition (BMI ? 25) among women in the age-group 20-49 for 36 low to medium countries within 95 surveys conducted between 1991 and 2008 and investigated the potential determinants of shift using the nationally representative survey data. Mamun and Finlay reported that the prevalence of underweight significantly declined for one in two countries and the prevalence of overweight increased significantly among 80% of the 36 countries.

In this paper, we have studied the association between mean BMI and point prevalence rates of obesity in the adult population among men living in 29 Indian states based on sampled data from NFHS-3.

Methods

Data for the present study is taken from NFHS-3. NFHS-3 covers a sample representative of 99% of the Indian population. NFHS-3 included 124,385 women aged 15 to 49 years and 74,369 men aged 15 to 54 years from 29 Indian states. The principal objective of NFHS-3 was to provide state and national estimates of fertility, family planning practices, infant and child mortality, maternal and child health and utilization of health services by mothers and children. The survey also includes information on the quality of health and family welfare services and provides indicators of the status of women, women's reproductive health and domestic violence. The survey provides state-level estimates of demographic and health parameters as well as data on various socioeconomic and programme dimensions, which are critical for bringing about the desired change in demographic and health parameters. The NFHS-3 was conducted under the scientific and administrative supervision of the International Institute for Population Sciences (IIPS), Mumbai, India. The institute conducted an independent ethics review of the 2005-06 NFHS protocol. Data collection procedures were also monitored and approved by the ORC Macro institutional review board (IIPS and Macro International 2007).

Random sampling technique was adopted for NFHS-3. The urban and rural samples with each state were drawn separately and were allocated proportionally to the size of state's urban and rural populations. In each state, the rural sample was selected in two stages, with the selection of villages at the first stage, followed by the random selection of households. In urban areas, a three stage procedure was followed. In the first stage, wards were selected with PPS sampling, followed by random selection of census enumeration blocks (CEB) and households (IIPS and Macro International 2007). The survey interviewed men and women of age groups 15 to 54 and 15 to 49 respectively and interviews were conducted in one of the

18 Indian languages along with English langue in respondents' homes with an 84.9% in men.

This study followed the WHO expert committee (2004) recommendation and modified guidelines given by the Health Ministry of India jointly with Indian Council of Medical Research for the new set of BMI classification for assessing overweight and obesity among the Asian population where people with a BMI ranging between 23 to 24.99 kg/m2 are classified as overweight and those with a BMI of more than or equal to 25 kg/m2 are classified as obese. In the present analysis we consider the adult men in the age group 20-54 and adult women in the age group 20-49 years.

Results

- Prevalence of obesity in Indian Adults

Using NFHS-3 data, we have estimated prevalence of obesity (BMI? 23) among Indian adults for the age-groups 20-39 and 40-54 in men. Results are presented in Table 1.

Figure 1 shows the BMI distributions of adult populations living in the five states with the lowest mean BMI and the five with the highest mean BMI values for men.

Table 1 Mean BMI and prevalence of obesity in adult men (20-54 years) in Indian states in adult populations

State	Mean BMI (all men)			Mean BMI (Non-obese)			Prevalence of Obesity (in %)(all men)		
	20-39	40-54	20-54	20-39	40-54	20-54	20-39	40-54	20-54
Jammu and Kashmir	20.69	21.21	20.84	19.61	19.58	19.62	19.31	26.15	21.25
Himachal Pradesh	20.85	21.66	21.13	19.64	19.53	19.69	20.43	33.25	24.92
Punjab	22.30	23.66	22.73	19.69	20.19	19.69	38.17	50.31	41.97
Uttaranchal	20.97	21.14	21.02	19.59	19.40	19.59	25.05	27.72	25.86
Haryana	20.84	21.55	21.05	19.39	19.31	19.38	22.99	33.21	26.01
Delhi	22.35	23.77	22.72	20.27	20.42	20.14	38.85	56.30	43.38
Rajasthan	20.01	20.67	20.22	19.09	19.12	19.11	14.64	22.97	17.28
Uttar Pradesh	20.15	20.58	20.28	19.11	18.98	19.22	15.62	21.60	17.36
Bihar	20.23	20.44	20.30	19.38	19.35	19.43	13.69	17.22	14.86
Sikkim	21.84	23.07	22.18	20.44	20.62	20.49	29.79	49.52	35.22
Arunachal Pradesh	21.15	21.50	21.25	20.17	19.99	20.16	21.74	30.04	24.15
Nagaland	20.99	21.61	21.17	20.24	20.29	20.22	16.77	26.56	19.66
Manipur	21.13	21.83	21.34	20.06	20.07	20.06	20.42	31.60	23.87
Mizoram	21.63	22.37	21.84	20.41	20.38	20.40	27.20	38.41	30.40
Tripura	19.80	20.02	19.87	18.87	19.20	18.87	15.35	14.86	15.18
Meghalaya	21.43	22.09	21.61	20.60	20.34	20.58	21.93	36.64	25.92
Assam	19.90	20.21	19.99	19.15	19.23	19.15	12.11	16.05	13.34
West Bengal	20.15	20.52	20.28	19.26	19.20	19.47	15.81	22.16	17.98
Jharkhand	19.86	20.39	20.03	19.09	19.21	19.16	12.35	19.37	14.58
Orissa	19.93	20.54	20.13	19.19	19.19	19.23	12.27	18.61	14.38
Chhattisgarh	19.83	20.39	20.00	19.09	19.13	19.13	11.77	19.11	14.04
Madhya Pradesh	19.60	20.37	19.84	19.07	19.12	19.29	9.03	19.52	12.32
Gujarat	20.36	21.95	20.89	18.96	19.31	18.95	20.11	36.27	25.46
Maharashtra	20.70	21.86	21.04	19.25	19.43	19.23	22.07	36.09	26.22
Andhra Pradesh	21.03	21.59	21.21	19.34	19.36	19.47	25.40	33.30	28.04
Karnataka	20.65	21.61	20.95	19.18	19.44	19.17	22.66	33.02	25.90
Goa	21.39	22.34	21.71	19.55	19.86	19.54	30.01	39.26	33.17
Kerala	22.04	22.49	22.22	19.77	19.83	19.77	37.24	45.30	40.46
Tamil Nadu	21.28	22.00	21.53	19.48	19.71	19.48	28.92	36.06	31.45

Figure 1: BMI distributions of adult male populations (20 to 54 years) from five states with the lowest and highest BMI mean

From Table 1 and Figure 1 we observed that the higher prevalence rates are observed for men from the south, north and west zones and the states Delhi, Kerala, Punjab and Sikkim and the changes in the distribution of BMI for the five states with highest and the lowest mean BMI values .

- Correlation between mean BMI and prevalence of obesity in Indian states

In this section, we have studied the association between mean BMI and point prevalence rates of obesity in the adult population among men living in 29 Indian states based on sampled data from NFHS-3.

The correlation between mean BMI and obesity prevalence for the total population was stronger and highly statistically significant in men (are reported in Table 2. After excluding obese individuals (BMI?23) from the calculation of the mean BMI, a moderate correlation was seen only in men (. When correlations were examined by age, the patterns were similar to those seen for the total population when obese individuals were not excluded.

Table 2 Association of mean BMI and prevalence of obesity in the adult men populations (20-54 years) Indian states

BMI	Age Group		p value		95% CI for
All	20-39	0.94	<0.001	9.76	8.41-11.12
Non-obese		0.54	0.003	8.75	3.34-14.17
All	40-54	0.98	<0.001	10.70	9.94-11.45
Non-obese		0.75	<0.001	17.11	11.18-23.05
All	20-54	0.96	<0.001	10.15	9.06-11.24
Non-obese		0.60	0.001	10.94	5.25-16.63

A one unit decrease in mean BMI was found to be associated with 10.1% lower obesity prevalence in men, When obese individuals were excluded, a significant relationship between "non-obese" mean BMI and obesity prevalence was seen in men, in whom a one unit reduction in mean BMI was related to a 10.9% decrease in obesity prevalence (Table 2). Significant and positive correlations were observed in all age groups. In men, ages 40-54 years showed stronger associations (10.7%) than

those seen in ages 20-39 years. The results of this study provide quantitative empirical evidence supporting the population based approach as an effective way to control obesity among India.

- **Conclusion and Discussion -**

A number of previous studies have reported the emergence of overweight and obesity in developing countries (Prentice, 2006; Kelly et al., 2008; Subramanian et al., 2011; Ng et al., 2014). According to Rose and Day (1990) as a distribution of a particular health related characteristic in a population shifts up or down as a whole, while keeping its dispersion unchanged, the mean and the prevalence of extreme values will be correlated. In the present study, the mean BMI of male adult populations of 29 Indian states is positively correlated with obesity prevalence. With the exclusion of obese individuals from the calculation of mean BMIs, the correlations are weak in male populations. Weaker correlations following the exclusion of higher BMI values suggest that the variance in obesity prevalence in the adult populations of Indian states are likely related not only to the displacement of BMI distribution, but also, as expected to the skewing of the curves towards high values, a finding that also been seen in the other populations (Rose and Day, 1990). The results from our study indicates that, in Indian states, obesity in adults should be understood not only as a problem restricted to high risk groups, but also that extend throughout the entire population.

In our study, in adult populations living in Indian states, a one unit decrease in population mean BMI is associated with a decrease in obesity prevalence ranging from 9.7% to 10.7%. This finding strengthens the evidence supporting the understanding of obesity as a response to an "obesogenic" environment, the control of which requires population-wide strategies. To the extent that it promotes high energy intake and reduced physical activity, the environment has an important role in the increasing prevalence of obesity (Papas et al., 2007). Living in locations that facilitate and promote physical activity, access to healthy foods, leisure activities, and reduced commuting time are some environmental factors that have been shown to be inversely associated with obesity (Papas et al., 2007).

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