J. Assam Sc. Soc. Vol. 57. No. 1 & 2 ISSN 0587-1921
December 2016; Pp. 56-66

ANALYSIS OF VARIATION IN BMI - A REGION WISE ANALYSIS

***Paramita Roy[1] and Amit Choudhury[2]**
[1] Department of Statistics, Gauhati University, Guwahati - 781014, India

Corresponding author: achoudhury@rediffmail.com, paramita_roy08@rediffmail.com

ABSTRACT

In this paper we present a picture of BMI variation among major states of India and to identify states with high as well as low BMI. This allows for implementation of necessary public health strategy to combat the devastating health consequences of both extremes of BMI. The analysis is based on a country wide large scale survey. An additional aim is to present a comparative study of BMI for different quartile boundaries of income across different zones for the selected age groups.

Key words: BMI, overweight, underweight, Kruskal-Wallis test, Mann Whitney Test

INTRODUCTION

Over the past few decades, India has experienced mutliple transitions with respect to economic development, nutritional status, fertility and mortality rates. In India, as a result of the nutritional transition, the prevalence of overweight has steadily increased mainly in the urban areas while undernourishment continues to be a major concern in rural areas (Griffiths and Bentley, 2001). Thus India is burdened with dual burden of malnutrition-undernutrition and overnutrition. However not all states of India experience dual burden of overweight and underweight. There exists variation in BMI among Indian states.

BMI is defined as the weight in kilograms divided by the square of the height in meters.

$$BMI = \frac{weight(kg)}{\{height(m)\}^2}$$ (Bharati et al., 2007)

Why does such state wise BMI variation exist in India? India is a country with a large, culturally diverse population (Dyson and Moore, 1983). These cultural differences may result in differences in eating patterns that serve to promote or suppress overeating leading to difference in BMI levels. In India, each state is practically equivalent to a country with its specific socio-economic level, different ethnic groups, food habits, health infrastructures and communication facilities. There exist diverse dietary profiles in India. Diet is expected to vary considerably within India across North-South regions (Shetty, 2002). Differences in food consumption patterns can contribute to variation in BMI. In addition, there is a wide variation in social policy between states (Peters et al., 2003). This difference in social policy may mean that while some state governments implement strong, well-funded policies to promote the distribution of food to those in need, other states may be less diligent in this regard (Subramanian et al., 2007). Shome et al. (2014) pointed out that variation in BMI can be observed in India because states are different with respect to socio-cultural context, economic condition, caste rigidity, difference in food pattern, strong gender inequality and so on.

Both low BMI and high BMI is detrimental to health. A BMI above and below the normal range increases the risk of morbidity and mortality and understanding the causes of a BMI out of the normal range may help prevent future disease. Obesity is associated not only with an increased burden of non-insulin diabetes, hypertension, cardiovascular diseases, some types of cancers and premature mortality but also with the social and psychological effects of excess weight (Bell et al., 2005). Obesity has been linked to an increased risk of numerous co-morbidities, including high blood pressure, high blood cholesterol, type 2 diabetes mellitus, coronary heart disease, osteoarthritis, asthma, and gallbladder disease (Mokdad et al., 2003). On the other hand, the chronic energy deficiency / underweight is associated with impaired physical capacity, reduced economic productivity, increased mortality and poorer reproductive outcomes (National Institute of Nutrition, 1991). Undernutrition is associated with increased comorbidities such as osteoporosis and diabetes (Gillespie and Haddad, 2001). Malnourished adults have lower work output in physical labour, earn less at work, are less productive, and are less likely to be hired as daily wage labour compared to better-nourished adults (Gillespie and Haddad, 2001).

BMI is the best and most popular indicator of nutritional status in adults. Thus the use of BMI as an anthropometric indicator of nutritional status may be more appropriate in a country with diverse ethnic groups such as India (Khongsdier, 2001). However, literature on BMI of adult Indians is limited to certain geographical areas or populations. As discussed earlier, the health consequences of high and low BMI are devastating, hence identification of states which are at risk for both extremes of BMI is necessary. This is in turn will allow us in formulating suitable policy necessary in curbing the rising epidemic of high BMI (overweight/obesity) as well as low BMI (underweight).

There are numerous factors for which BMI varies across populations. Lifestyle indicators, socioeconomic status, and dietary habits influence BMI level. Chhabra and Chhabra (2007) observed that older subjects, females, urban residents, and those from the higher-economic group had greater odds for being overweight or obese. However, for the present study we have chosen the factor-income. It is well known that BMI increases with age. According to our data mean BMI increases till 50 years and then shows a declining trend (Figure 1). So for our analysis we have considered two age groups-22-35 years (young adults) and 36-50 (middle aged). Physical activity level, diet, income differs among young and middle aged, which in turn lead to difference in BMI among the two mentioned age groups. This fact highlights the importance of a study on BMI among the age groups and to examine if BMI differs among different zones of India for different quartile boundaries of income.

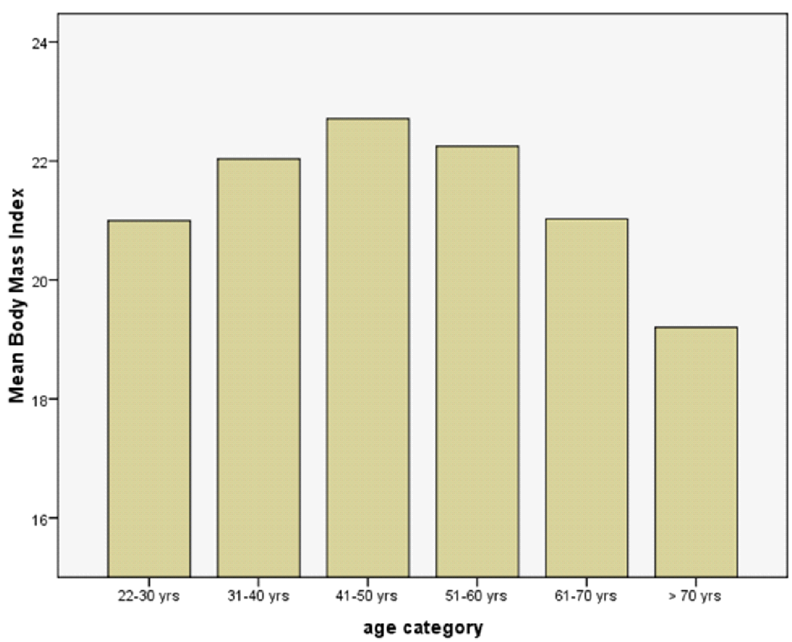

Fig. 1. Agewise distribution of mean BMI

MATERIALS AND METHODS

In this paper, we have used data from the Indian Human Development Survey (IHDS), 2005. IHDS was jointly carried out by University of Maryland and the National Council of Applied Economic Research (NCAER) India. It is a nationally representative multi topic survey of 41,554 households in 1503 villages and 276 towns and cities across all states and union territories of India except Andaman Nicobar and Lakshadweep islands. It includes both individual and household level responses on various topics such as education, employment, health, fertility, and gender relations. Stratified sampling design was used for selecting the sample from all over the country.

The India Human Development Survey is the first household survey in India to have a full spectrum of health, education, economic, family, and gender modules for both urban and rural samples. IHDS (2005) has two major datasets- Individual dataset and Household dataset. Our analysis was carried out on the individual dataset which consists of 2,15,754 cases, each with 211 variables. The household dataset has 41,554 cases each with 937 variables.

15 major states are considered for the present study. Major states consist of the following: Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. India can be divided into six geographical zones: North zone, East zone, West zone, South zone, Central zone and North–east zone. These zones and the respective states are:

a) North zone: Haryana, Punjab and Rajasthan
b) East zone: Bihar, Orissa and West Bengal
c) West zone: Gujarat and Maharashtra
d) South zone: Andhra Pradesh, Karnataka, Tamil Nadu and Kerala
e) Central zone: Uttar Pradesh and Madhya Pradesh
f) North-east zone: Assam

For the analysis, we have used various statistical measures and various statistical tests. Among the measures we have used mean, median etc. In whatever follows, it has to be understood that whenever 'mean BMI' is used it means mean BMI of the samples. For example, in Table 1, we have stated that mean BMI of North zone is 22.56, it means that the mean BMI of the sample of north zone is 22.56. In a different context, 22.56 can be seen as an estimate of BMI of North zone. Similarly for other measures like median BMI etc.

For the analysis, Kruskal-Wallis test has been conducted for examining if median BMI differs among different quartile boundaries of income for the two selected age groups across different zones.

The Kruskal-Wallis test is a non parametric technique which analyzes whether there is a difference in the median values of three or more independent samples. "This test collects all data instances from the samples and ranks them in increasing order. If two scores are equal, it uses the average of the ranks to be given. The rank sums are then calculated and the Kruskal Wallis test statistic (H) is calculated as per the following equation:

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \left(\frac{R_j^{\,2}}{n_j} \right) - 3(N+1)$$

where R_j = rank sum of each sample

$$N = \sum_{j=1}^{k} n_j$$

n_j = number of samples for each group

k = number of groups" (Nahm, 2016)

Mann Whitney U test is used to analyze differences berween the medians of two datasets. "The Mann Whitney U test initially implies the calculation of a U statistic for each group….. Mathematically the Mann Whitney U statistics are defined by the following, for each group:

$$U_x = n_x n_y + ((n_x(n_x + 1))/2) - R_x$$

$$U_y = n_x n_y + ((n_y(n_y + 1))/2) - R_y$$

where n_x is the number of observations or participants in the first group, n_y is the number of observations or participants in the second group, R_x is the sum of the ranks assigned to the first group and R_y is the sum of the assigned to the second group….

If the numbers of observations and are larger than eight, a normal approximation, as shown by Mann and Whitney (1947), can be used, that is to say:

$$\mu_u = (n_x n_y)/2 = (U_x + U_y)/2 \text{ and}$$

$$\sigma_u = \sqrt{((n_x n_y)(N + 1))/12}$$

where, corresponds to the average of the U distribution and corresponds to its standard deviation.

If each group includes more than eight observations, tha sample distribution gradually approaches a normal distribution. If a normal approximation has to be used, the corresponding equation becomes:

$$z = (U - (n_x n_y / 2))/\sigma_U$$

and the test statistic becomes, in absolute values:

$$|z| = |U_x + U_y|/\sigma_U$$

If the absolute value of the calculated z is larger or equal to the tabulated z value, the null hypothesis is rejected." (Nachar, 2008)

For statistical tests, any *p* value less than 0.05 is considered as significant. Data were analyzed using SPSS.

Data cleaning

Data cleaning has been done for height and weight data. Weight less than 35 kg or more than 150 kg have been discarded from the variables 'weight1' and 'weight 2' of IHDS database. For cleaning height data, values less than 121.9 cm (i.e. 4 ft) have been discarded.

After exclusions and data cleaning from individual dataset of IHDS (2005), 1,16,255 cases are analyzed.

Construction of new variables

Some variables needed for our analysis are not included in the IHDS (2005) database. These have been constructed in order to proceed with the analysis. For example BMI (Body Mass Index) is one of the risk factors of chronic disease. As this variable is not included in individual IHDS data, we have constructed the same. This is possible because individual height and weight data is available. The variable per capita income using total income and household size has been constructed. Then quartiles for this variable have been constructed.

Exclusion criteria

Analysis of BMI is restricted to population aged 22 years and above.

Recoding of variables

We have categorised some of the scale variables and recategorised a few of the categorical variables as follows.

i) BMI is coded as Underweight (BMI<18.5 kg/m), Normal Weight (18.5 kg/m<BMI<24.9 kg/m) and Overweight (BMI>25 kg/m). These categories are used worldwide.

ii) The constructed variable "familial per capita income" is classified into four categories viz. less than 1^{st} quartile, 1^{st}-2^{nd} quartile, 2^{nd}-3^{rd} quartile and 3^{rd}-4^{th} quartile. The quartile boundaries are less than Rs 3600, between Rs 3601 to Rs 6949, Rs 6950 to Rs 13872 and Rs 13873 through highest.

ANALYSIS AND DISCUSSION

1. This section presents scenario of mean BMI of major states in different zones of India for
   a) all age group considered
   b) selected age groups 22-35 years and 36-50 years

Mean BMI have been computed for major states of India and is given in Table 1.

Table 1. Estimates of Mean BMI for major states of India

	Estimates of Mean BMI
North Zone	22.56
Haryana	22.02
Punjab	24.05
Rajasthan	21.60
East Zone	21.35
Bihar	21.00
Orissa	20.77
West Bengal	22.27
West Zone	21.31
Gujarat	21.58
Maharashtra	21.04

South Zone	22.25
Andhra Pradesh	22.08
Karnataka	21.06
Tamil Nadu	22.67
Kerala	23.20
Central Zone	21.00
Uttar Pradesh	21.13
Madhya Pradesh	20.87
North East Zone	22.48
Assam	22.48
All India	21.79

From Table 1, we find that major states falling in West Zone and Central Zone have mean BMIs less than all India mean BMI value. In North Zone, mean BMI values of Haryana and Punjab are greater than All India mean BMI value. The same can be said for West Bengal falling in East Zone. Except Karnataka, other major states falling in South Zone have mean BMI values greater than all India mean value. Assam, the single major state falling in North east Zone has mean BMI value greater than all India mean value.

Table 2. States with estimates of mean BMI in descending order for age group 22-35 years and 36-50 years

<table>
<tr><th>States with estimates of mean BMI in descending order for age group 22-35 years</th><th>States with estimates of mean BMI in descending order for age group 36-50 years</th></tr>
<tr><td>Punjab (23.37)</td><td>Punjab (24.98)</td></tr>
<tr><td>Kerala (22.61)</td><td>Kerala (23.83)</td></tr>
<tr><td>Assam (22.35)</td><td>Tamil Nadu (23.12)</td></tr>
<tr><td>Tamil Nadu(22.32)</td><td>West Bengal (23.01)</td></tr>
<tr><td>West Bengal (21.68)</td><td>Andhra Pradesh (22.99)</td></tr>
<tr><td>Haryana (21.59)</td><td>Haryana (21.59)</td></tr>
<tr><td>Andhra Pradesh (21.54)</td><td>Assam (22.67)</td></tr>
<tr><td>Rajasthan (21.10)</td><td>Gujarat (22.41)</td></tr>
<tr><td>Gujarat (20.98)</td><td>Rajasthan (22.35)</td></tr>
<tr><td>Uttar Pradesh (20.74)</td><td rowspan="3">Uttar Pradesh (21.76)
Bihar
Karnataka</td></tr>
<tr><td>Maharashtra (20.61)</td></tr>
<tr><td>Karnataka (20.54)</td></tr>
<tr><td rowspan="2">Madhya Pradesh (20.47)
Bihar</td><td>Maharashtra (21.69)</td></tr>
<tr><td>Madhya Pradesh (21.48)</td></tr>
<tr><td>Orissa(20.45)</td><td>Orissa(21.23)</td></tr>
</table>

According to the analysis, Punjab has the highest mean BMI. This may be due, at least in part, to agricultural advances that have made the area a net food exporter (Tiwana et al., 2005), as well as cultural shifts in which sedentary behavior and a calorie-dense diet have gained wide appeal (Sidhu et al., 2006). Our analysis also reveals the fact that Orissa has the lowest mean BMI. This may be due to greater proportion of tribals living in Orissa. Orissa, has largest number (62) of tribal communities (62 tribes including 13 primitive tribes) with a population of 8.15 million constituting 22.3% of total population of Orissa State (Census of India, 2001) and half of them is living below poverty line (Mahapatra et al., 2000). The manifestation of such poor living condition leads to high prevalence of chronic energy deficiencies (low BMI) among tribal communities of Orissa.

2. To examine if median BMI differs among different zones of India for young adults with less than 1st quartile income we have computed Kruskal-Wallis test and found p value to be significant. Thus we may infer that there exists significant difference in median BMI of young adults with lowest quartile boundary of income among different zones of India Hence pairwise comparison is necessary among different zones. Significant differences can also be observed in median BMI of young adults of other quartile boundaries of income among different zones of India. Similar results have been observed while analysing BMI of middle aged of different quartile boundaries among zones of India. The results of pairwise comparison among different zones of India for each of the quartile boundary of income are presented in Tables 3 and 4.

Table 3 : Pairwise comparison of BMI of different zones for people with different types of quartile boundaries of per capita income in 22-35 years

Pairwise comparison between BMI of	p value using Mann Whitney test for persons with Less than 1st quartile income in 22-35 years age group	p value using Mann Whitney test for persons with 1st-2nd quartile income in 22-35 years age group	p value using Mann Whitney test for persons with 2nd-3rd quartile income in 22-35 years age group	p value using Mann Whitney test for persons with 3rd -4th quartile income in 22-35 years age group
North vs East zones	0.000*	0.000*	0.615	0.266
North vs West zones	0.000*	0.000*	0.000*	0.000*
North vs South Zones	0.000*	0.007*	0.799	0.898
North vs Central zones	0.000*	0.000*	0.056**	0.021*
North vs North East zones	0.000*	0.001*	0.001*	0.724
East vs West zones	0.059**	0.023*	0.000*	0.000*
East vs South Zones	0.001*	0.001*	0.687	0.202
East vs Central zones	0.164	0.947	0.024*	0.001*

East vs North East zones	0.000*	0.000*	0.002*	0.501
West vs South Zones	0.335	0.000*	0.000*	0.000*
West vs Central zones	0.397	0.020*	0.009*	0.009*
West vs North East zones	0.000*	0.000*	0.000*	0.000*
South vs Central zones	0.025*	0.000*	0.028*	0.018*
South vs North East zones	0.000*	0.000*	0.001*	0.691
Central vs North East zones	0.000*	0.000*	0.000*	0.020*

* denotes significant at 5%
** denotes significant at 10%

Table 4. Pairwise comparison of BMI of different zones for people with different types of quartile boundaries of per capita income in 36-50 years

Pairwise comparison between BMI of	p value using Mann Whitney test for persons with less than 1st quartile in -come in 36-50 years age group	p value using Mann Whit ney test for persons with 1st-2nd quartile income in 36-50 years age group	p value using Mann Whitney test for persons with 2nd-3rd quartile income in 36-50 years age group	p value using Mann Whit-ney test for persons with 3rd - 4th quartile in 36-50 years age group
North vs East zones	0.000*	0.000*	0.417	0.696
North vs West zones	0.000*	0.000*	0.000*	0.000*
North vs South Zones	0.008*	0.015*	0.139	0.101
North vs Central zones	0.000*	0.000*	0.000*	0.535
North vs North East zones	0.009*	0.560	0.743	0.001*
East vs West zones	0.634	0.565	0.001*	0.000*
East vs South Zones	0.000*	0.003*	0.671	0.038*
East vs Central zones	0.941	0.377	0.006*	0.699
East vs North East zones	0.000*	0.011*	0.963	0.000*
West vs South Zones	0.000*	0.000*	0.000*	0.000*
West vs Central zones	0.676	0.127	0.650	0.000*
West vs North East zones	0.000*	0.002*	0.016*	0.658

South vs Central zones	0.000*	0.035*	0.004*	0.064**
South vs North East zones	0.000*	0.375	0.706	0.010*
Central vs North East zones	0.000*	0.039*	0.043*	0.001*

* denotes significant at 5%
** denotes significant at 10%

For the two selected age groups, most of the pairwise comparison of different zones of BMI of persons with per capita income less than 1st quartile, similar results have been obtained, with exception of the pairs East and West, West and South. Out of the 15 pairwise comparisons, differences are observed in only four pairwise comparisons for persons with income lying between 1st-2nd quartile. Differences are observed in North and North East, East and West, West and Central, south and North where significant p values have been obtained for 22-35 age group where non significant p values have been obtained for 36-50 age group. Noticeable differences are observed in North and North East, West and North East, West and Central, South and North East zones where significant p values have been obtained for 22-35 age group whereas non significant p values have been obtained for 36-50 age group for pairwise comparison of persons with income lying between 2nd-3rd quartile. For the two selected age group, a maximum seven dissimilar results have been obtained among the pairwise comparison of zones for BMI of persons lying in the highest quartile boundary of income group.

CONCLUSION

High as well as low BMI have adverse health effects. Effective prevention and management of high and low BMI are necessary in states of Punjab (state with high BMI) and Orissa (state with low BMI) respectively.

For both age groups considered, significant differences has been observed while examining BMI of persons belonging to lowest quartile boundary of income for different zones. Similar conclusion can also be drawn while examining BMI of persons belonging to other quartile boundaries of income. However if both age groups are considered, another trend is also noticeable. As compared to people of lower income categories, people of higher income group show increasing trend of having similar BMI. The reason is quite obvious. People of higher income have higher purchasing power due to which intake of calorie dense junk food is high among them. Hence they have similar food consumption pattern resulting in similar BMI. According to the analysis, people of lower income categories show significant difference in BMI in most of the pairwise comparison of zones. It is perhaps due to difference in food habits.

REFERENCES

1. Bell C.G., Walley A.J. and Froquel P. (2005) The genetics of human obesity. *Nature Reviews Genetics*, 6: 221-234
2. Bharati S., Pal M., Bhattacharya B.N. and Bharati P. (2007) Prevalence and causes of chronic energy deficiency and obesity in Indian women. *Human Biology,* 79(4): 395-412
3. Census of India (2001) Provisional population totals (Orissa), Paper-1, Series 22
4. Chhabra P. and Chhabra S.K. (2007) Distribution and determinants of body mass index of non-smoking adults in Delhi, India. J*ournal of Health, Population and Nutrition*, 25(3): 294–301
5. Dyson T. and Moore M. (1983) On kinship structure, female autonomy, and demographic behavior in India. P*opulation and Development Review*, 9(1) :35–60
6. Khongsdier R. (2001) Body mass index of adult males in 12 populations of northeast India. *Annals of Human Biology*, 28: 374–383
7. Gillespie S. and Haddad L. (2001) Introduction. In attacking the double burden of malnutrition in Asia and the Pacific. ADB Nutrition and Development series No 4 Asian Development Bank, Manila, Phillipines and International Food Policy Research Institute, Washington, DC, USA: 1-4.
8. Griffiths P. L. and Bentley M. E. (2001) The Nutrition Transition is Underway in India. *Journal of Nutrition*, 131(10): 2692-2700
9. IHDS (2005) India Human Development Survey. ICPSR22626-v8. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [Distributor], 2010-06-29. doi:10.3886/ICPSR22626.v8
10. Mahapatra A., Geddam J.J., Marai N., Murmu B., Mallick G., Bulliyya G., Acharya A.S. and Satyanarayana K. (2000) Nutritional status of preschool children in the drought affected Kalahandi district of Orissa. *The Indian Journal of Medical Research*, 111: 90-94
11. Mokdad A.H., Ford E.S., Bowman B.A., Dietz W.H., Vinicor F., Bales V.S. and Marks J.S. (2003) Prevalence of Obesity, Diabetes, and Obesity-Related Health Risk Factors, 2001. JAMA, 289 (1): 76–79
12. Nachar N. (2008) The Mann –Whitney U: A Test for assessing whether two independent samples come from the same distribution. *Tutorials in Quantitative Methods in Psychology*, 4(1): 13-20
13. Nahm F. S. (2016) Nonparametric statistical tests for the continuous data: the basic concept and the practical use. *Korean Journal of Anesthesiology*, 69(1): 8-14
14. National Institute of Nutrition (1991) Body Mass Index and Mortality Rates: A Ten Year Retrospective Study, *Annual Report, 1989–90. Hyderabad: National Institute of Nutrition*
15. Peters D.H., Rao K.S. and Fryatt R. (2003) Lumping and splitting: the health policy agenda in India. *Health Policy and Planning*, 18(3): 249–260
16. Shetty P.S. (2002) Nutrition transition in India. *Public Health Nutrition*, 5: 175–82
17. Shome S., Roy P., Pal M. and Bharati P. (2014) Variation of Adult Heights and Weights in India: State & Zonewise Analysis. *Human Biology Review*, 3 (3): 242-257
18. Sidhu S., Kaur N. and Kaur R. (2006) Overweight and obesity in affluent school children of Punjab. *Annals of Human Biology,* 33(2): 255–259
19. Subramanian S.V., Kawachi I. and Smith G.D. (2007) Income inequality and the double burden of under- and over-nutrition in India. *Journal of Epidemiology and Community Health*, 61(9): 802–809
20. Tiwana N.S., Jerath N., Saxena S.K., Nangia P. and Parwana H.K. (2005) Punjab State Council for Science & Technology. Punjab, Chandigarh, India. State of Environment