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Bio-social Evaluation of Adiposity Levels in Women: Reinventing the Ecological Model Approach

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Abstract: *Purpose:* To examine the socio-cultural-demographic and reproductive factors as underlying determinants of obesity.It also tends to understand the dynamics of various factors that act on contributory lines and consequently influence the incidence and management of 'conventional prognosticators of chronic disease' with the help of facets of ecological theory.

Methods: A cross-sectional sample of 698 women of three different ethnicities and geographical regions were included in the study. Two tribal populations-Tangkhul Nagas from Manipur and Siddis of Gujarat with urbanites of Delhi Punjabi Khatri-Arora were studied for socio-demographic- economic and reproductive determinants of obesity. The differences in anthropometrics of given populations were tested by ANOVA and student's t-test.

Separate regression models tests were used for each population with obesity markers as dependent variables and social determinants as independent variables.

Results: Odds of socio-demographic indicators as predictors of overweight/obesity were higher for those who- have education equivalent to schooling, being a homemaker, being married, living in a nuclear family, having less than 3 meals a day, a higher preference and frequency of non-vegetarian consumption. Reproductive factors and perception about health and physical activity were also found to be crucial determinants of obesity.

Conclusion: Irrespective of genes, clustering of social and cultural factors like physical inactivity, irregular and unhealthy eating patterns family structuring, marital status and some social disadvantage forms an intricate mesh. This web provides an alternative intrinsic explanation for the social gradient of obesity in women. The various determinants identified in the present study through ecological models, are seen to have the potency to influence multiple health behaviors and health outcomes.

Keywords: Ecological model, khatri – aroras, obesogenic, siddis, social determinants, tangkhul nagas, women health.

INTRODUCTION

WHO defines social determinants of health as 'the conditions in which people are born, grow, live, work and age, including the health system' [1]. Numerous studies have suggested that 'social factors or social determinants of health are key predictors of health outcomes and are critical contributors to health disparities' [2, 3] although health specialist harbor a notion that when we take care of the basic sphere of social causation holistically, the socio-cultural predictors are easily be addressed individually.

This has veiled the real potential social, cultural and environmental factors might carry as determinants of chronic diseases. Due to consistent findings that women possess overwhelmingly large number of social correlates steering their adiposity levels; it is mandatory to investigate biological, environmental, and socio-cultural factors that predispose women to life style diseases.

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Numerous factors interact at different levels to create an imbalance between the energy consumed and the expenditure, leading to obesity. As these interactions are complex and not essentially one - way networks, the actual casual pathway remains indistinguishable. These factors are diet patterns, levels of physical, socio-demographic variables etc. Though these are core determinants of obesity, they are in-turn influenced by various biological, environmental and cultural factors. For early life, a holistic model would include genes, biology, environment, culture and lifestyle can be documented as potential risk factors for obesity [4-8].

Various short term concerns short-term consequences e.g. social discrimination, lower quality of life, increased cardiovascular risk factors, diseases like asthma [9] and long-term consequences e.g. 'persistence of obesity, increased morbidity, a higher prevalence of cardiovascular risk factors in adulthood' [4, 10] causes an important economic burden [10] and deterioration in quality of life.

Obesity in women has been associated with a variety of factors, including genetic predisposition, social class, and early age at menarche, exercise, alcohol consumption and diet [11]. Obesity can make some serious

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physiological, biochemical, metabolic, anatomical, psychological and social alterations and understanding these might be a key to analyze and provide valuable insights to the health status of women. Obesity might also have deleterious effects for women of reproductive age. There is significant difference in mortality and morbidity patterns between obese and non-obese women [12, 13], where values are high for former and the progeny of these mothers is known to be at a greater risk of developing non-communicable disorders like CVD's, diabetes and obesity [14, 15]. Therefore, it is vital to understand the causes and cultural correlates of this epidemic and what remedies can be utilized to help prevent it especially in women. What constitute these environmental factors - sedentary behavior (like physical inactivity, long TV viewing hours, variable sleeping/resting hours) which is associated with increase in body fat [16]. Besides this, social cultural determinants like socioeconomic status, specific parental determinants (occupation, income, migration status, level of education0, dietary patterns and food choices are some of the known risk variables [17]. Demographic parameters like marital status, family size, family type can also be elementary prognosticators of health status. In addition, there exist also regional variations especially in India, which determines the niche and the availability of resources in one's habitat. Reproductive health status might also serve as variable for determining adiposity levels of the bearer and her progeny. WHO limits

'Social determinants of health to economic and social conditions – and their distribution among the population – that influence individual and group differences in health status' [1, 2]; yet this study defines combines biological, socio-cultural and economic factors either directly or as a consequential parameter of these major domains. Extensive researches have contributed to an abundant body of literature reflecting the relationship between obesity and its correlates such as lipid profiles, hypertension, high blood sugar levels (diabetes) [18-21]. Whereas, only a handful of studies have been put forth for understanding social determinants such as dietary patterns; self- reported physical activity (PA), health status, occupation, income, education, marital status, family type in unison [22]. In this article, we tend to advocate the modeling of social determinants as casual factors of obesity and not undermine their usability by just limiting them to factors that juxtaposed with conventional obesity correlates (lipid profiles-cholesterol levels; hypertension, lifestyle patterns, physical activity-sedentary life). This is because we propose the dynamics social elements can act on contributory lines and consequently influence the incidence and management of 'conventional prognosticators of chronic disease' with the help of facets of ecological theory.

2. MATERIAL AND METHODS

2.1. Methods

2.1.1. Characteristics of the Population

698 women of three different ethnicities and geographical regionsranging in age from 20 to 70 years through a cross-sectional survey in India. A cohort of Tangkhul Nagas women were studiedduring the period November 2005 to March 2006and among Siddis of Gujarat and Punjabi Khatri-Arora women of Delhi during October 2011- December 2012. A cross-sectional design with convenience sampling was used for recruitment of women in the present study. Tangkhul Nagas of Manipur, Siddis of Gujarat and Punjabi Khatri-Arora women of Delhi were studied to understand socio-demographic-economic and reproductive determinants of obesity. With the objective to delineate the effect of environment, Tangkhul Naga women were divided into two groups-hill (rural) and plain (urban) for comparisons after controlling for genes. Women with specific physiological conditions like pregnancy or in lactation period were excluded from the sample.

Institutional Ethical committee approved the study protocol and the all studies were compliant with ethical standards. Informed consent was obtained from all subjects included in the study. Research purpose and techniques were explained and demonstrated respectively to each subject and only those who willingly volunteered were included written informed consent were studied.

Tangkhul Nagas: Thestudy included 346 Tangkhul Naga women anda door-to-door and snowballing survey was carried out in Ukhrul district as well as Imphal valley, where many Tangkhuls migrated from Ukhrul district and are now settled in the capital city of Manipur, north-east India. This migration has resulted in urbanization with ways being borrowed from neighboring dwellers.

'Tangkhul Nagas constitute the major bulk of the population of Ukhrul district of Manipur though there are also a small percentage of Kukis, Nepalese and other non-tribals in the area. In Manipur, Tangkhuls are the second largest tribe, constituting 19.7% of the state's total Scheduled Tribes (ST) population. Tangkhul Naga, one of the sub-groups of the Naga tribe, is of Mongoloid stock, and linguistically they belong to the Tibeto-Burman, which is within the Sino-Tibetan language family. Traditionally the main sources of income of the people were agriculture, in which both terrace and wetland farming are practiced, along with small-scale industries, animal husbandry, forest resources and rivercatches.

The staple food of the Tangkhul Nagas is rice.With growing urbanization there has been a major shift in their occupation and many of them have taken up business and jobs in both public as well as private sectors, though some of them are still engaged in farming. With modernization and economic development, improvement in socioeconomic status and lifestyle over the years has been observed among the Tangkhul Nagas' [23, 24].

Siddis of Gujarat: TheSiddis (Afro-Indians) are a particularly vulnerable tribal group (PVTG's) of Gujarat placed in rural settings. 'There are about 250 000 Afro-Indians, i.e. Indians of African origin, in India, settled in the state of Gujarat bordering Pakistan and, in the states of Andhra Pradesh in south-central India (former Kingdom of Hyderabad), Maharashtra (formerly Bombay State), Kerala and Karnataka in the south, and the former Portuguese

territories of Daman, Diu and Goa. In Gujarat they are found in the districts of Ahmedabad, Amerili, Jamnagar, Junagadh, Rajkot, Bhavnagar, Broach/Bharuch near Ratanpur, and the former Kingdom of Cutch/Katchch' [25].

The present study was carried out in Junagarh district of Rajkot. Siddis are agriculturists and also daily-wage workers with Bajra and rice being their staple food. Groundnut oil is the cooking medium. Siddis are marked by very high physical activity levels by occupations. Siddis have borrowed urban life-ways from contiguous Gujarati urbanites in certain lifestyle factors such as nutrition and transportation.

Punjabi Khatri-Aroras: The presentstudy is based on a cross-sectional survey of189 women, conducted in Delhi, an urban center of India.'Khatri is the Punjabi adaptation of Sanskrit word Kshatriya. They are traditionally members of the Hindu military order and they are a dominant community of north-western India and have emerged as one of the most progressive and dynamic communities in recent years. TheKhatris are a north Indian community that originated in the Potwar Plateau of Punjab. Khatri and Arorasare known to have common ancestry and also cross-marry' [26, 27]. Khatris-Aroras are completely modernized in food patterns, choices and occupations which are not physically demanding. They are involved in business and jobs. Wheat is the staple food. The food patterns show that there has been a considerable increase of fat-rich diet and processed foods, and absolute involvement in fast-food culture. Recently, it has been noticed that fast food diet constitutes major portion of daily meals in Punjabis. It is because they have been relying on processed/packaged food for cooking and also by eating out at restaurants and food kiosks.

2.2. Research Proformas

Socio-demographic factors such as age, income per month, education, occupation, marital status, family type, dietary habits (type of diet and number of meals etc), recalled physical activities, and self-reported health status were included in the analysis. Reproductive factors like recalled age at menarche, parity, duration of menstrual period and its cycle length were recorded for the subjects during interviews using structured schedules.

2.3. Anthropometric Data

From the numerous biometric variables available in the data set, following variables that were representative of the general inclusive parameters of the sample population were chosen for this study:

Anthropometric measurements like stature, weight, waist circumference, hip circumference and skin fold thickness at various sites (biceps, triceps, subscapular, suprailliac, calf posterior) were taken using standard technique [28].

Body mass index (BMI), Grand mean thickness (GMT), Waist hip ratio (WHR), and Weight height ratio (WHtR) were computed statistically. In order to assess overweight and obesity, body mass index (BMI) was calculated (Weight (kg)/Height^2 (m)). The study participants were classified on the basis of BMI following WHO International Standard and recommended cut-off points for Asians (for Tangkhul Nagas, a mongoloid population) [29, 30]. Forabdominal obesity among females, WHR cut off points of 0.80 and above was followed [31]. WHtR cut off points was taken at 0.50 [32]. Gender specific cut offs for abdominal obesity as defined by WC has been taken as 80 cm in women [33]. Grand mean thickness (GMT) was calculated as mean of all the skinfold thicknesses measured.

2.4. Analysis

Descriptive statistics for various parameters have been displayed with their Standard deviations. To test the effect of the independent nominal variables on the continuous dependent variables, ANOVA and student's t test were used. Anthropometric parameters were reported in relation to ethnicity and geographical location. Regression models tests, for all socio economic, demographic, and reproductive variables were used for all populations separately to predict and quantifying the occurrence of a chronic condition by risk categories of BMI, WC, WHR and WHtR. SPSS 17 has been used for data analysis and full results of these tests are available on request.

2.5. Theory Involved

The variables involved in the analysis were chosen with the help of ecological theory. It accounts for a multilevel approach, suggesting that' health is contingent on as plurality of interacting contexts. It offers a 'valuable way of looking at complex community conditions, and exploring potential links between social determinants and health' [34]. This specific ecological model is an adaptation of the model developed by Sweat and Denison (1995) [35]. This multi-level model organizes potential social determinants of health at five levels and then adapted for the present study dealing with a chronic condition (obesity) and adiposity levels as shown in Fig. (**1**):

1. The individual (traits and behaviors)-The study would consider food patterns of the populations and reproductive parameters.

2. The relational (relationships, social support): Demographic data involving marital status and family type.

3. The environmental (built environment): Ethnicity and geographical location

4. The structural (laws, policies, and politics): Categories like Caste, Schedule tribes and rural-urban dynamics.

5. The super-structural (social justice issues such as racism, disadvantage due to low socioeconomic status, sexism): Socio economic status of given populations.

The present model further postulates that these levels of ecological models together constitute the environmental and socio-cultural norms of a particular region which drives the behavior and community habits. An individual's unhealthy practices or adaptations that are those known to predispose to certain conditions might just provide an appropriate environment for detrimental genes (associated with chronic

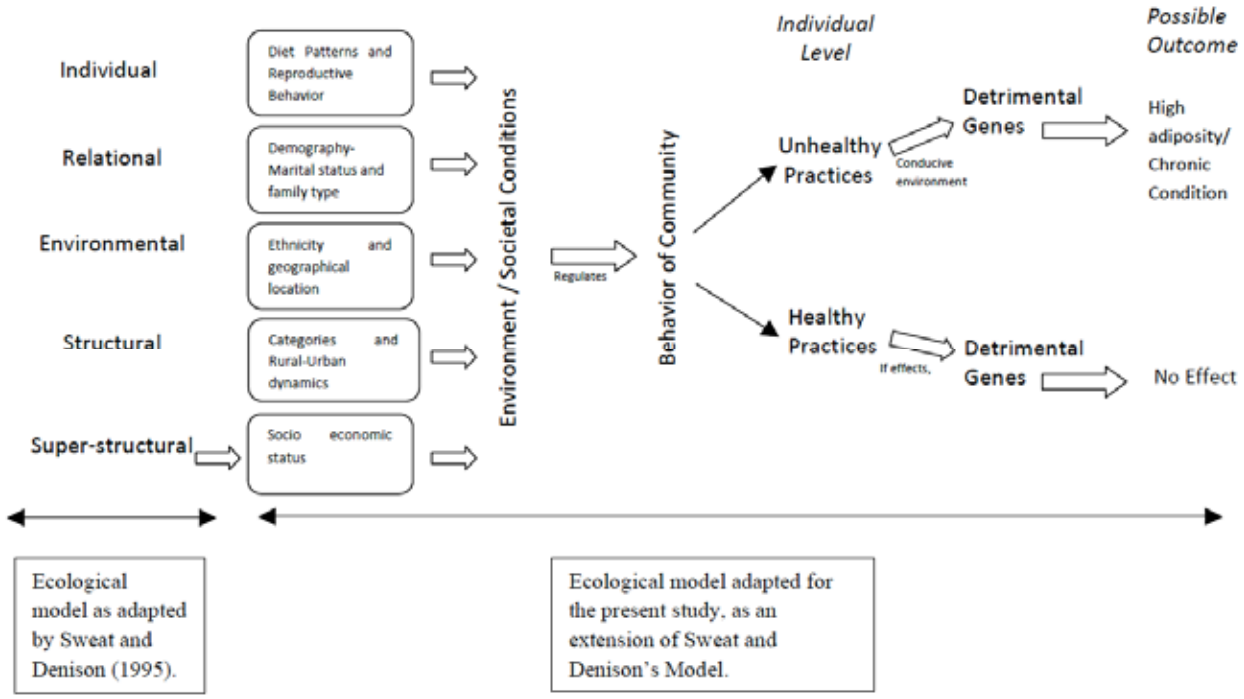

Fig. (1). Multi-level model for potential social determinants of health at five levels, adapted for chronic condition (obesity) and adiposity levels.

conditions and other diseases) for their complete expression. On the other hand, lack of conducive environment for detrimental genes due to healthy physiology and habits might result in absolutely no harmful effect. Effect of each variable has been put forth in statistical terms.

RESULTS

(Table **1**) shows mean and comparative evaluation of various variables. F-test between the populations shows that the differences in mean values of all the anthropometric variables and obesity indices were statistically significant. Body weight, height, skinfold thickness and circumferences showed significant differences among rural and urban Tangkhul Nagas. General obesity indices, BMI and GMT showed significant differences between hill and plain Tangkhul Nagas while there were no significant differences with regard toregional obesity indices, waist-stature ratio and waist hip ratio. There were statistically significant differences in the mean values of all the anthropometric variables and obesity indices between Siddis of Gujarat and Punjabi Khatris-Aroras of Delhi.

(Table **2A**) shows cross tabulations between risk categories of various obesity indices and socio- economic, variables. For rural populations, socio-economic status comprising of schooling as education levels, being homemakers by occupation and an income less than 5000 rupees showed highest individuals falling in risk categories through all adiposity markers. Graduate urban women, business professionals, and homemakers were seen to be overweight/obese. WHR seems to be estimating obesity at the higher end while least risk numbers were predicted by WHtR across all strata. (Table **2B**) shows the odds of socio-demographic indicators as predictors of overweight/obesity as based on BMI, WC, WHtR and WHR. As evaluated from educational status, among Siddis being illiterate was a significant risk factor for development of overweight/obesity as assessed from BMI when compared to those with school education, whereas among Punjabi Khatris-Aroras higher education was a risk factor. Central obesity evaluation showed low educational status to be a significant risk factor for central obesity in Siddis and both urban as well as rural Tangkhul Nagas. In Punjabi Khatris-Aroras, higher education was found to be a significant risk factor for development of central obesity. Assessment with occupation showed homemakers at risk of developing over weight/obesity when compared to students in most of the population under study.

(Table **3A** and **3B**) show cross tabulations between risk categories of various obesity indices and demographic variables and odds of demographic indicators as predictors of overweight/obesity as based on obesity indices, respectively. Results indicate that more married women fall in risk categories when compared to their single counterparts. Also, women residing in nuclear families tend to be overweight/obese (nearly 60-80%) through all given obesity markers. Married hill women of Tangkhul Nagas showed 2-4 times higher odds of falling in risk categories through BMI, WC and WHtR while Khatri women of Delhi documented nearly 5 times higher risk of falling in chronic categories.

Irrespective of rural or urban backgrounds, having 2 meals as against 3 poses a high risk of obesity in women as shown in (Table **4A**). Siddi and Punjabi Khatri-Arora women who had more than 3 meals had least percentage of individuals falling in risk categories through WHR and WHtR. Food preferences like non-vegetarian food over

Table 1. Mean, S.D and comparative evaluation of anthropometric variables and obesity indices.

Variables	Mean ± S.D		t-test for differences between a,b	Mean ± S.D		t-test for differences between c,d	F-test between all populations
	Tangkhul Nagas of Manipur						
	Hill (Rural)[a] N=157	Plain (Urban)[b] N=189		Siddis of Gujarat[c] N=167	Punjabi Khatris-Aroras of Delhi[d] N= 185		
Age (years)	42.08 ±16.53	37.21 ±13.84	-3.00*	36 .07±12.87	34.76±12.56	-14.09*	23.81**
Body Weight (kg)	46.84 ±5.99	50.21 ±7.02	4.27**	55.01 ±12.01	56.66±13.63	3.99**	31.33**
Height (cm)	150.58 ±7.62	151.89 ±4.98	2.22*	158.83 ±8.94	156.56±5.56	11.22**	37.78**
Biceps Skft (mm)	3.6 ±2.00	6.19 ±2.23	5.05**	5.61 ±1.31	5.54±3.66	-4.65*	48.14**
Triceps Skft(mm)	4.4 ±3.67	12.57 ±4.18	7.11**	11.01 ±4.21	13.53±5.74	1.04*	56.00**
Subscapular Skft (mm)	4.8 ±4.06	12.63 ±3.95	3.16**	11.59 ±6.19	13.06±4.50	2.38*	20.43**
Suprailliac Skft (mm)	4.2 ±5.63	16.71 ±5.56	2.08**	10.76 ±6.24	12.81±3.87	6.74*	67.56**
Waist Circumference (cm)	75.68 ±9.90	77.80 ±9.07	5.81*	75.37 ±11.08	79.87±10.01	-7.50*	42.90**
Hip circumference (cm)	86.21±3.09	87.98±2.67	1.23*	89.27±5.69	86.87±5.89	-1.66	4.86**
BMI (kg/m^2)	20.59 ±2.62	21.75 ±2.80	3.95*	22.69±3.42	23.28±5.63	-5.84*	27.38**
Waist Stature Ratio	0.50 ±.07	0.51 ±0.06	ns	0.52 ±0.09	0.51±1.08	-11.44**	2.94**
Waist Hip Ratio	0.87 ±0.08	0.87 ±0.08	ns	0.82 ±0.06	0.80±11.08	-6.81**	17.28**
Grant mean thickness (mm)	11.20 ±3.01	13.71 ±3.12	6.51**	13.45 ±4.52	12.47±2.67	-14.09**	5.77**

** p<0.001, *p< 0.05

Table 2A. Cross tabulation between risk categories of obesity indices and Socio-economic Status (in percentages).

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
Socio-economic Status	Education	Illiterate/No formal Education	7.7	6.3	28.6	0	14.3	7.8	19.6	0	14.5	5.8	22.4	0	12.5	4.6	22.6	0
		Schooling	84.6	73.4	61.9	4.7	81	80.5	76.7	4.4	82.9	77.9	69.7	3	82.8	78.4	73.5	3.2
		Gradution	3.8	12.5	7.1	65.9	2.4	6.5	1.9	67.1	1.3	9.6	3.9	76	3.1	12.4	2.4	65.2
		Post-graduation	3.8	7.8	2.4	29.5	2.4	5.2	1.9	28.5	1.3	6.7	4.9	21	1.6	4.6	1.6	31.6
	Occupation	Student	7.7	20.3	7.1	4.3	9.4	13	1.9	3.3	7.9	20.2	7.9	3	15.6	24.2	15.7	4.2
		Government Service	7.7	10.9	9.5	19.5	9.5	11.7	7.4	21.4	10.5	10.6	3.9	22	7.8	9.2	5.5	19.2
		Private Job	3.8	1.6	2.4	14.1	4.8	3.9	3.7	14.3	2.6	3.8	2.6	16	2.3	6.5	1.6	18.4
		Business and others	3.8	1.6	11.9	19.4	3.8	2.6	18.5	20.7	5.8	1.9	15.8	20	4.8	3.3	15	24.3
		Homemakers	61.5	56.3	64.3	42.7	60.1	59.7	64. 8	40.3	59.2	55.8	59. 2	39	53.9	51.0	54.3	33.9
		Agriculturalist	15. 4	9.4	4.8	0	1 2.4	5.2	3.7	0	13.9	4.8	3.9	0	1 5.5	3.9	7.9	0

Table 2A. contd….

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
	Income per month (rupees)	<5000	61.5	56.7	57.1	3.51	52.4	44.15	57.4	8.3	63.2	25	59.1	5	57.8	26.8	58.3	6.8
		5000-10000	19.2	34.4	28.6	35.14	28.6	11.7	25.9	38	23.7	37.5	30.2	38	25.8	36.6	27.6	26.6
		>10000	19.2	8.9	14.3	61.35	19	44.15	16.7	53.7	13.2	37.5	10.7	57	16.4	36.6	14.2	66

* Asian BMI cut off

Table 2B. ORs through socio-economic status indicators as predictors of overweight/ obesity with various obesity markers.

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
Socio-economic Status	Education	Illiterate/No formal Education	-	-	2.76	-	1.19	1.01	1.98	-	1.76	-	2.01	-	-	-	2.79	-
		Gradution	-	-	-	3.65	-	-	-	2.78	-	-	-	1.56	-	-	-	2.32
		Post-graduation	-	-	-	3.98	-	-	-	3.13	-	-	-	-	-	-	-	-
		Schooling	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a
		Business	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.87
		Agriculturalist	1.46	1.87	-	-	-	-	-	-	2.12	1.74	-	-	-	-	-	-
		Government Service	-	-	-	2.13	-	-	-	-	-	-	-	3.43	-	-	-	3.54
		Private Job	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.12
		Homemakers	1.45	-	2.67	2.56	-	-	-	2.32	1.23	-	3.32	3.87	-	-	4.54	2.87
		Student	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a
	Income per month (rupees)	<5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		>10000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		5000-10000	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a

* Asian BMI cut off
All values are significant at <0.05 levels
0^a is the reference category.

Table 3A. Cross tabulation between risk categories of obesity indices and demographic variables (in percentages).

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
	Marital Status	Single	15.4	26.6	14.3	32.2	9.5	19.5	9.3	5.4	15.8	25.0	15.8	25	20.4	32.0	23.6	32
		Married	80.8	67.2	81	62.2	90.5	74	87	67.4	84.2	69.2	81.6	69	77.2	63.4	70.0	63.4
		Others	3.8	6.3	4.8	5.4	0	6.5	3.7	27.2	0	5.8	2.6	6	2.3	4.6	6.4	4.6

Table 2A. contd….

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
	Family Type	Nuclear	92.3	87.5	71.4	89.2	95.2	90.9	87.4	80.2	90.8	89.4	77.6	90	87.5	88.2	80.4	88.2
		Joint	7.7	7.8	11.9	6.8	4.8	5.2	12.6	6.5	9.2	7.7	9.2	7	12.5	9.8	12.6	9.8
		Extended	0	4.7	16.7	4.1	19	3.9	0	13.3	0	2.9	13.6	3	0	2.0	7.0	2

* Asian BMI cut off

Table 3B. ORs through demographic variables as predictors of overweight/ obesity with various obesity markers.

		BMI				WC				WHtR				WHR			
		Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
		Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
	Married	3.76	-	-	-	2.45	-	-	-	2.43	-	2.11	-	-	-	-	-
	Others	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Single	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a
Family Type	Nuclear	3.87	2.65	-	4.98	4.12	4.34	-	-	2.98	2.92	-	5.01	3.91	3.54	3.09	4.65
	Extended	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Joint	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a	0^a

* Asian BMI cut off
All values are significant at <0.05 levels
0^a is the reference category.

Table 4A. Cross tabulation between risk categories of obesity indices and dietary habits (in percentages).

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
Dietary Habits	No. of meals	2	65.4	68.8	85.7	56.8	81	67.5	92.6	64.1	69.7	71.2	69.8	76	67.7	71.2	62.4	70
		3	34.6	31.3	9.5	25.7	19	32.5	5.6	22.8	30.3	28.8	27.6	18	31.3	28.8	35.2	28.8
		>3	0	0	4.8	17.6	0	0	1.9	13	0	0	2.6	6	0	0	2.4	11.2
	Food Preference	Veg	0	0	19.1	33.33	0	0	18.5	13.4	0	0	30.3	28	0	0	12.6	36.6
		Non veg	100	100	80.9	66.67	100	100	81.4	86.9	100	100	69.7	72	100	100	87.4	63.4
	Frequency of non-veg	Daily	50.1	82.8	57.1	83.8	66.7	18.2	57.4	81.5	46.1	82.7	53.9	53	82	36.1	52	86.1
		Weekly	42.3	15.6	42.9	13.5	33.3	80.5	42.6	16.3	53.9	14.4	38.1	39	10.2	30.6	44.9	8.3
		Sometimes	7.6	1.6	0	2.7	0	1.3	0	2.2	0	2.9	7.9	8	7.8	33.3	3.1	5.6
	Eating out	Regular	80.6	57.8	59.5	70.3	90.5	68.8	75.9	61.8	85.5	62.5	70.9	61	82.0	59.5	82.7	59.5
		Irregualr	11.7	26.6	23.8	24.32	7.1	19.5	24.1	31.5	10.5	26.9	20.1	28	10.2	26.8	9.4	26.8
		Never	7.7	15.6	16.7	5.38	2.4	11.7	0	3.1	3.9	10.6	8.9	11	7.8	13.7	7.9	13.7

* Asian BMI cut off

Table 4B. ORs through dietary habits as predictors of overweight/ obesity with various obesity markers.

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
Dietary Habits	No. of meals	2	-	-	2.61	-	2.31	2.09	4.23	-	3.32	3.97	2.19	1.98	-	-	-	1.81
		>3	-	-	-	0.87	-	-	-	-	-	-	-	-	-	-	-	0.91
		3	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
	Food Preference	Non veg	-	-	4.53	3.87	-	-	2.98	5.23	-	-	-	3.12	-	-	4.09	2.76
		Veg	-	-	0[a]	0[a]	-	-	0[a]	0[a]	-	-	0[a]	0[a]	-	-	0[a]	0[a]
	Frequency of non-veg	Daily	1.32	1.98	-	2.68	-	-	-	3.78	1.78	3.11	-	-	2.43	-	-	-
		Weekly	-	-	2.56	-	-	3.34	2.23	-	-	-	-	-	-	-	-	-
		Sometimes	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
	Eating out	Regular	2.87	2.02	1.21	2.21	3.87	-	2.33	-	3.43	-	1.43	-	2.97	1.08	2.15	1.98
		Irregular	-	-	-	-	-	-	-	2.45	-	-	-	-	-	-	-	2.13
		Never	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]

* Asian BMI cut off
All values are significant at <0.05 levels
0[a] is the reference category.

Table 5A. Cross tabulation between risk categories of obesity indices and reproductive determinants (in percentages).

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
Reproductive Determinants	Menstrual Problems	Yes	73.1	62.5	78.6	66.2	69	57.1	72.7	64.1	65.8	59.6	75.4	60	68.8	62.7	63.3	62.7
		No	26.9	37.5	21.4	33.8	31	42.9	27.8	35.9	34.2	40.4	24.6	40	31.3	37.3	300.7	37.3
	Duration of cycle	≤ 3Days	56.5	53.1	64.3	55.4	52.4	51.9	57.4	48.9	59.2	49	55.3	47	61.7	52.9	59.1	52.9
		4-5 days	30.8	35.9	23.8	35.1	31.0	36.4	27.8	40.2	27.6	40.4	34.3	42	26.6	37.3	29.1	27.3
		≥ 6 days	7.7	10.9	11.9	9.5	16.7	11.7	14.8	10.2	13.2	10.6	10.5	11	11.7	9.8	11.8	7.8
	Parity	0	15.4	26.6	16.7	25.7	14.3	28.6	13	27.2	15.8	26	10.5	28	21.1	24.8	9.1	4.6
		1-3	61.5	43.8	16.3	41.2	16.9	48.1	66.7	42.4	55.3	44.2	55.8	44	46.1	37.9	30.5	32.5
		4-7	19.2	26.6	14.3	33.1	11.9	20.8	11.1	30.5	18.4	26.9	15.8	28	25.8	32.7	42	62.9
		>7	3.8	3.1	4.8	0	11.9	2.6	9.3	0	10.5	2.9	17.9	0	7.0	4.6	10.4	0

* Asian BMI cut off

vegetarian choices, having non- vegetarian food daily, eating out regularly has clear associations with women falling in risk categories through all adiposity indices irrespective of population in question. In (Table **4B**) concludes dietary habits assessment showed that those who took meal twice a day were more likely to be centrally obese than those who took meal three times a day. Non vegetarian food habits as well as higher frequency of non-vegetarian food consumption and eating out were significant risk factor for development of obesity in all the populations.

(Table **5A**) shows that presence of menstrual problems i.e. having periods for less <3 days or 4-5 days and with increase of parity, more than 50% women were seen to be overweight/obese. (Table **5B**) shows the odds of reproductive determinants as predictors of overweight/obesity as

Table 5B. ORs through reproductive determinants as predictors of overweight/ obesity with various obesity markers.

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
Reproductive Determinants	Menstrual Problems	Yes	2.68	1.98	2.11	-	-	-	-	2.31	1.78	1.07	-	2.78	2.02	2.13	-	-
		No	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
	Duration of cycle	≤ 3Days	1.34	2.23	326	-	-	-	2.67	-	2.11	1.78	2.45	-	-	-	3.87	3.41
		≥ 5 days	-	-	-	-	-	-	-	1.95	-	-	-	-	-	-	-	-
		4-5 days	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
	Parity	1-3	2.34	2.01	-	2.45	-	1.87	3.24	3.16	2.43	2.11	3.25	3.45	1.21	1.06	-	-
		4-7	-	-	-	1.78	-	-	-	-	-	-	-	-	-	-	2.43	3.66
		>7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		0	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]

* Asian BMI cut off
All values are significant at <0.05 levels
0[a] is the reference category.

Table 6A. Cross tabulation between risk categories of obesity indices and perception about health (in percentages).

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
Perception about Health	Self-Reported health	Average	26.9	35.9	28.6	32.4	28.6	36.4	29.6	37	30.3	35.6	30.1	33	32.0	34	31.5	34
		Good	23.1	28.1	19	29.7	23.8	22.1	20.4	26.1	26.3	29.8	19.7	31	26.6	34	20.8	32
		Bad	50.0	35.9	52.4	37.8	47.6	41.6	50	37	43.4	34.6	50.2	36	41.4	32	47.7	34
	Self-Reported Physical activity	Light	88.5	87.5	83.3	83.8	69.0	87	75.9	83.7	78.9	74.1	80.1	86	83.6	85.6	83.5	62.9
		Moderate	3.8	12.5	9.5	16.2	16.7	11.7	18.5	15.2	11.8	25.9	12.8	13	10.2	13.7	10.2	32
		Heavy	7.7	0	7.1	0	14.3	1.3	5.5	1.1	9.2	0	7.1	1	6.3	0.7	6.3	5.1

* Asian BMI cut off

based on BMI, WC, WHtR and WHR. It can be concluded that those who had menstrual problems and whose menstruation cycles were less than 3 days, were more likely to be obese. Parity between 1-2 showed significant risk factor for obesity when compared to those who had no children, among all the populations.

20-35% women who perceived their health to be average and 34-50% who perceived their health as bad come under the risk of being overweight or obese as shown in (Table **6A**). Similarly, nearly 80% women who associated themselves with light physical activity were overweight or obese. (Table **6B**) reports odds through as assessed from self-reported physical activity, those with light physical activity level were more likely to be overweight/obese when compared to those with heavy physical activity level in all the populations.

DISCUSSION

The accelerating increase in obesity in the world has been labeled as an "epidemic" by public health officials all over

Table 6B. ORs through perception about health as predictors of overweight/ obesity with various obesity markers.

			BMI				WC				WHtR				WHR			
			Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras	Tangkhul Nagas*		Siddis	Punjabi Khatris-Aroras
			Hill	Plain			Hill	Plain			Hill	Plain			Hill	Plain		
Perception about Health	Self-Reported health	Average	-	-	-	-	-	-	-	2.39	-	-	-	-	-	-	-	-
		Bad	2.87	-	-	-	-	-		-	-	-	-	-	-	-	-	-
		Good	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
	Self-Reported Physical activity	Light	4.56	3.31	-	3.45	-	-	2.03	3.78	1.12	1.09	-	6.21	2.78	2.97	3.76	2.18
		Moderate	-	2.43	-	-	-	-	-	-	-	1.91	-	-	-	-	-	
		Heavy	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]

* Asian BMI cut off
All values are significant at <0.05 levels
0[a] is the reference category.

the globe. The rise has been distinctively evident since 20th century but the gradient of this increase in the last decade is matter of concern. What contributes to obesity has always been the most elementary query of researchers-genetics, environment, culture or socio-demographic parameters. Each of them, have been discretely studied as a determinant of this chronic condition. This manuscript tends to comprehend the contribution of these factors independently and in unison to adiposity levels and to estimate risk of obesity in three different populations. The results of the present paper superlatively display the fact that three biologically different populations are posed at a comparable and almost equate able risk of obesity by various adiposity indices through social and cultural determinants. Numerous obesity markers tend to predict the levels of obesity in a population but the results show how these markers at times underestimate or overestimate risk categories. Tangkhul Nagas of Manipur, a scheduled tribe were divided into two groups on the basis of their abode. With hill residers are known to be rural populations, the Plain dwellers of Imphal valley are known to have undergone major changes in the last 100 years. Dynamics has been consistent with transition in their religious practices, traditional way of life, physical activity levels, income and occupation and dietary patterns. Coherent alteration in lifestyle has brought about complete shift in fat distribution pattern of the body along with physiological functions, inclusive of change in general health paradigms.

There is absolutely no element of doubt that these two populations who otherwise shared a complete gene pool differ only on cultural and environmental grounds. Urbanization can be seen as an essential determinant of health problems in Tangkhul Nagas. An increase in obesity is a well-articulated consequence of these problems, especially among women of both divisions but the comprehendible differences are cultural in nature [36, 37]. The levels of education, income and occupation have risen considerably resulting in apprehensible change in dietary patterns, demographic features and perceptions of health. Education, it seems has a U-shaped association with diet and its pathway is laid down by socio- economic status. Highly educated individuals are generally associated with higher income groups and hence, have greater probability of eating processed food/eating out. Lowest education group deals with lack of knowledge about nutrition and lack of resources to buy nutritive diet. Again both groups seem to have no alliance to exercise; while former lacks time and later the assets. The differences between Siddis of Gujarat and Punjabi Khatris- Aroras are due to additive effect of genes and environment as the former are tribesmen residing in rural setting and the latter are urbanites of Delhi. Urbanization tends to provide an 'obesogenic' niche to its dwellers and hence, the urban Nagas and Punjabi Khatris-Aroras of Delhi are heavier, fatter and a higher percentage of these populations fall in risk categories of adiposity levels when compared to rural Nagas and Siddis of Gujarat respectively.

Tangkhul Nagas are ere usually lean, an absolute contrast to the mainland Indian or the western populations. The absence of profound odds in some obesity estimators for Tangkhul Nagas and Siddis might be explained with the fact Naga women have slender waist and hips, resulting in doubtful Waist-Hip ratio equaling 1. The ratio might hence overestimate individuals falling in risk categories. While Siddis of Gujarat, known for their African descent were steatopygic and hence this prognosticators tend to underestimate risks with ratio being much lower than real estimates. Herskov its (1948) quoted, "Culture is the screen between man and nature, and hence none of the changes in body composition of humans can be explained by genes and biology alone [38]. It implies that neither culture, nor biology and environment alone, can determine health status. The epidemic rise in obesity finds it roots in dramatic dynamics of diet, socioeconomic status, change in family structures, drop in levels of physical activity and revolutionary health practices.

Lifestyle patterns physical activity levels, psychological problems arising from working conditions, income levels are to be potent contributors to the rise in obesity epidemic [39,40] along with demographics [41]. The present study showed how highest numbers of obese females were found in categories with minimum education as schooling, homemakers through occupation and monthly income < 5000 rupees in rural/tribal populations.

Various underlying path ways involving the relationship between education levels, factors associated with socio-economic status, unhealthy eating habits (nutrition), reduced levels to complete absence of recreational PA and occupational activity, together are associated with obesity. Lack of health consciousness (not keeping a track of things that are related to good health) and a drop in health demographics (life expectancy, fertility etc.) are often linked to the low socio-economic status. While in urban women, obesity is a consequential of transition in trends in nutritional patterns and those in way of lives. These women are known to consume a more energy-rich, processed, refines diet and a recorded drop in physical activities (due to mechanization of various household chores).

Obesity was also found to be higher in married women and those who residing in nuclear families as for these women, their own well-being becomes secondary once married and as they are sole care providers in nuclear families. The metabolic consequences of the consumption of a diet depend, in part on the frequency, choice and distribution of meals. Women who took meals twice a day were found to have higher chance of obese and overweight as compared to those who took three meals a day. In a study by women subjects who took 2-3 meals per day showed greater BMI indices and a greater proportion were overweight/obese compared to those who took 4-5 meals per day [42]. Meals more than 3 in number tend to provide a protective gear (9-11% lesser chances) against obesity. Also, regularly eating out and daily intake of non-vegetarian food has led to a rise in obesity in all women irrespective of genes and environment in the preset study. Similar results have been documented by Kapoor *et al.* [22]. The duration of menstrual period of less than 3 days and presence of any type of menstrual problem has been found to be a greater risk factor for obesity among the adult women of all populations. Concern about the increased prevalence of obesity has heightened interest in the relationship between parity and body weight. The increased parity among the present subjects posed risk for both general and central obesity. It has been reported that there is a significant positive correlation between parity, mean BMI and WC as women with higher parity had higher mean body mass index and WC, than their counterparts with lower parity, This can be explained by an increase in weight (post-partum) due to multiple births. Furthermore, this coupled with physical inactivity and a sedentary lifestyle predisposes multiparous women prone to NCD's [4-7, 22, 42, 43]. Repeated pregnancy outcomes can have a compounding effect on obesity levels as Indian women are fed high calorie diet both pre- and post-pregnancy. Reproductive outcomes are also culturally driven. Indian women are known to fed with very high calorie and protein based diet pre-pregnancy in order to be strengthened enough to deliver a healthy baby and post pregnancy to regain the lost nutrients. Early menarche has always been associated with increased body weight, body fatness and body mass, and hence good nutrition. As early menarche indicates good maternal health and nutrition and a physique associated with increased birth weight, one might then assume that early menarche would be associated with positive reproductive outcomes [44]. Lack of physical activity poses a high risk for obesity as shown in these results in all populations.

Swinburn *et al.* concluded there is a precise correlation between levels of obesity and sedentary lifestyle, increased consumption of energy dense foods, showing a positive trend. While an explicit negative correlation explains the association of between regular physical activity and a high intake of non-starch polysaccharides [45]. Moreover, an increase in physical activity levels especially aerobic has been documented as an effectual strategy in preventing the obesity epidemic [46].

This study tends to identify potential social determinants of health amongst tribal andurban community in India. They together provide a comprehensive framework for understanding the multiple and interacting determinants of health behaviors and further impending risk of adiposity and chronic condition. All levels individually and also in comprehension are seen to be contributing to obesity irrespective of ethnicities, location and categories. What differs is the intensity as for the categories like ST's, PVTG's or rural-urban status, might determine access to certain facilities, yet each of the given population shows how environment is contributing to the levels of obesity. The study employed an anthropological approach of contextual issues in the community, which can be aimed at designing community-based interventions at multiple ecological levels. The various determinants identified in the present study, are seen to have the potential to impact a variety of health behaviors and health outcomes.

These are pertinent indicators of wide range of adiposity levels that occur across various communities in India. Ecological model targets multiple influences of health behavior and this approach with supportive environmental factors can be used in designing effective health promotion programs. More importantly, ecological models can be used to develop intervention strategies that systematically target mechanisms of change at each level of influence. A paucity of research has been available to fuel the ongoing measurement and description of women's health in association with its social gradient. In the present study, irrespective of genes, clustering of social and cultural factors like irregular and unhealthy eating patterns family structuring, marital status and some social disadvantages forms an intricate mesh. This web provides an alternative intrinsic explanation for the social gradient of obesity in women.. The various determinants identified in the present study through ecological models, are seen to have the potency to influence multiple health behaviors and health outcomes.

While these social factors provide a conducive environment for genes of obesity to breed, the extent is modifiable. An essential element to obesity is, change in body composition where accumulation of fat is still

genetically driven. This implies that across generations, the body type of females has remained same though the fat percentage has increased tremendously in both urban and rural females. There are however several limitations to our study. The self-report nature of data collection with respect to exercise, physical activity, and diet patterns may have an element of bias incorporated through the respondents. Limited numbers of variables have been used for the present study, as only these variables were common in all study populations. Locally fabricated cut-offs around the mean values for duration of menstrual period, parity, income have been used in the study as no applicable standards could be located in the literature.

CONFLICT OF INTEREST

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ABBREVIATIONS

BMI	=	Body Mass Index
CVD's	=	Cardiovascular Disorder
WHR	=	Waist Hip Ratio
WHtR	=	Waist Height Ratio
PA	=	Physical Activity
SES	=	Socio-Economic Status

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