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Age, period and birth cohort effects on prevalence of obesity among reproductive-age women in India

Dinesh Chaurasiya [a], Ajay Gupta [a], Shekhar Chauhan [b,*], Ratna Patel [c], Vaishali Chaurasia [a]

[a] Department of Mathematical Demography and Statistics, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai, 400088, India
[b] Department of Population Policies and Programs, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai, 400088, India
[c] Department of Public Health and Mortality Studies, International Institute for Population Sciences, Govandi Station Road, Deonar, Mumbai, 400088, India

1. Introduction

The prevalence of obesity has been rising in India as well as in other countries (Balarajan & Villamor, 2009; Flegal, Carroll, Ogden, & Johnson, 2002; Garg, Khan, Ansari, & Garg, 2010; Ogden et al., 2006; Wright & Aronne, 2012). In a systemic analysis of epidemiological studies from 199 countries, around 1.46 billion people worldwide were estimated to be overweight in 2008, and of these 502 million were obese (Finucane et al., 2011). Excess body weight is associated with adverse health outcomes on longevity, disability-free life years, quality of life, and productivity (Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). Overweight and obesity has created an additional burden in correlation with several other diseases worldwide. The burden of obesity includes diabetes, coronary heart disease, stroke, cancer, and osteoarthritis (Wang et al., 2011). For a country like India, Obesity has not yet become a priority on the policy front. India being the developing nation going through the dual burden of obesity on one side while the high undernourishment on the other. According to the latest round of National Family Health Survey (NFHS-4, 2015–16), 20.7% percent women and 18.9 percent men are overweight or obese as compared to 12.6 percent women and 8.9 percent men in 2005–06 (NFHS-3) (IIPS, 2007; IIPS, 2016).

Obesity is the accumulation of body fat to that level, which may harm health. A person having more than 20 percent of body weight as fat is considered obese. Body Mass Index (BMI) is a widely used diagnostic tool to measure obesity. Obesity is one of the most infuriating problems in developing countries (Stein, 2004).

Obesity and its risk factors have been studied in India widely using different approaches. However, no study has been undertaken using Age-Period-Cohort (APC) analysis from a repeated cross-sectional sample survey in the Indian scenario. In this type of analysis, individual observations are nested within time-periods and cohorts. Age-period-cohort (APC) analysis has been used by epidemiologists to identify and interpret temporal changes in health characteristics or behaviours of a population. One common goal of APC analysis is to assess the effects of one of the three factors on some outcomes of interest net of the influences of the other two time-related dimensions (Yang & Land, 2016). Assessment of age-, period- and cohort effects in obesity prevalence can shed light on the validity of the over-nutrition hypothesis as well as other fresh hypotheses that attempt to explain materialistic increases in obesity in India.

Thus, the aim of this study is to differentiate between the effects of age, period, and birth cohorts on the prevalence of obesity among Indian reproductive-aged women using the data from three different time-periods. Also, the study will try to look at the differences in these effects across caste groups and residence among Indian women.

1.1. Age-period-cohort measure

Birth cohort provides a unique set of experiences for the people born at a particular time-period. The people born in different cohort experience different set of activity, to say, people born just after the country got independence would have suffered a lot because of ensuing food scarcity, regular wars at the front. Those who were born after 1980 would have experienced a technological advancement with greater availability of everything they needed. Cohort analysis of obesity is one of the neglected dimensions and had never been discussed before in the Indian context.

Very limited research on the topic of discrimination between the effects of age, period, and cohort is available (Allman et al., 2008). One of the critical explanations been given for this is the inherent problem of non-identification because these three variables vis. Age, period, and cohort are not independent of each other. Two of the three variables define the third; for example, age is determined by birth year and period. Similarly, birth year determines the completed age in year. There are few studies which have explored the effect of birth cohort on the prevalence of overweight and obesity but used only one additional factor, age or period, in the analysis (Prentice & Jebb, 1995; Koski, Jousilahti,

& pietinen, 2001; Stevens, Jones, & Arnett, 2003). A regression model, APC model, is proposed that allows all three parameters to be included by using constraints (Holford, 1991). The model works on the fact that the effect of the birth cohort is important in time trends of many diseases. The APC model derives the birth cohort by subtraction of age from the period when representative study populations are used.

2. Methods

2.1. Data sources

We have used the data from three rounds of the Indian Demographic Health Survey viz. National Family Health Survey (NFHS)-2, NFHS-3, and NFHS-4, conducted in 1998–99, 2005–2006, and 2015–16, respectively. The NFHS is a nationwide survey conducted with a representative sample of households using uniform questionnaires throughout the country, initiated by the Ministry of Health and Family Welfare (MOHFW), Govt. of India and coordinated by International Institute for Population Sciences (IIPS), Mumbai. NFHS-2 comprises 92,486 households and 90,303 ever-married women. Unlike the earlier surveys, NFHS-3 interviewed all women age 15–49 and all men age 15–54.NFHS-3 collected information from a nationally representative sample of 109,041 households, 124,385 women aged 15–49, and 74,369 men aged 15–54 years, while NFHS-4 has interviewed 699,686 women, for a response rate of 97 percent and 112,122 men with a response rate of 92 percent from 601,509 successfully interviewed households. In NFHS-2, the household response rate was 98 percent, and the individual response rate was 96 percent while in NFHS-3, the household response rate was 98 percent, eligible response rate was 94.5 percent while eligible men response rate was 87 percent.

2.2. Statistical analysis

BMI provides the most useful population-level measure of overweight and obesity as it is same for both sexes and all ages of adults. However, it should be considered a rough guide because it may not correspond to the same degree of fatness in different individuals. Data on body mass index of women were extracted from all three rounds of NFHS and pooled. Sample weights for different rounds are adjusted for pooling of three rounds. For analyses, BMI was dichotomized into a categorical variable for obese (BMI$\geq$ 25) and not obese (BMI$<$ 25). Age was subtracted from period (i.e., year of study) to identify birth cohorts. Cohorts were arranged into 4-year groups with the initial cohort (1948–1952) and last cohort (1998–2002), which covered a broader range of years to ensure a sufficient number of subjects. Age is measured in single-year increments. In caste group 1, Schedule caste (SC) and Schedule Tribe (ST) were taken. All other caste was coded as caste group 2. To show the differential, the age-wise prevalence of obesity was calculated for both place and caste group.

For multivariate analysis, we adopted a hierarchical APC (HAPC) approach and specified cross-classified random-effects models (CCREMs) that estimate fixed effects for age and its quadratic term, but that estimate random effects for periods and birth cohorts by treating these variables as level-2 factors[11]. To get a proper interpretation for random effects, the coefficient of random effects were converted into predicted probability, and from that predicted probabilities, risk ratio has been calculated by taking year 2006 and birth cohort 1973–77 as a reference category (See Table 1A attached as supplementary material). The mathematical equation can be expressed for them as below:

Level 1 model:

$$Logit\text{Pr}\left(Outcome_{ijk}=1\right) = \beta_{0jk} + \beta_1 A_{ijk} + \beta_2 A^2_{ijk}$$

Level 2 model:

$$\beta_{0jk} = \gamma_0 + u_{0j} + v_{0k} \, , \ u_{0j} \sim N\left(0, \tau_u\right), \ v_{0k} \sim N\left(0, \tau_v\right)$$

Table 1
Age wise prevalence of Obesity among Indian Women by place of residence and Caste Group.

Age in Single Year	Total	Place of Residence		Caste Group	
		Rural	Urban	Caste Group 1	Caste Group 2
15	2.79	1.83	5.18	2.05	3.11
16	3.05	1.99	5.69	2.04	3.49
17	3.71	2.37	6.86	2.43	4.25
18	4.50	3.25	7.59	2.76	5.26
19	5.44	3.95	8.78	4.61	5.81
20	6.40	4.83	10.02	4.74	7.13
21	8.10	6.02	12.27	5.98	9.00
22	9.20	6.78	14.29	7.13	10.10
23	10.40	7.69	16.09	8.07	11.39
24	12.07	9.11	17.84	8.92	13.36
25	12.96	9.61	20.16	9.25	14.54
26	15.03	10.70	23.16	11.25	16.66
27	16.38	11.64	25.42	13.42	17.62
28	17.22	12.54	26.67	11.75	19.46
29	20.27	14.42	30.35	14.65	22.49
30	19.38	14.19	30.27	14.43	21.54
31	22.50	15.81	34.47	16.01	25.11
32	23.03	16.74	35.25	17.06	25.38
33	24.62	17.25	37.78	17.45	27.52
34	25.69	17.83	39.83	18.48	28.36
35	23.94	17.68	36.82	17.88	26.38
36	27.20	19.58	41.06	19.53	30.15
37	27.85	19.61	42.07	18.72	31.29
38	26.58	19.54	39.83	19.75	29.20
39	28.62	20.45	41.75	20.99	31.49
40	27.48	19.71	43.22	19.80	30.62
41	29.74	20.21	45.85	21.38	32.83
42	30.65	21.12	47.95	21.49	34.00
43	31.41	22.09	47.22	21.33	34.89
44	32.76	22.86	49.29	22.69	36.39
45	29.84	21.90	45.83	21.91	32.96
46	32.81	23.46	49.63	22.88	36.41
47	31.52	22.99	47.14	21.38	35.28
48	32.96	24.37	48.66	23.21	36.68
49	33.50	23.74	50.66	22.57	37.62
TOTAL	18.19	12.85	28.86	12.84	20.37

Combined model:

$$Logit\text{Pr}\left(Outcome_{ijk}=1\right) = \gamma_0 + \beta_1 A_{ijk} + \beta_2 A^2_{ijk} + u_{0j} + v_{0k}$$

For $i = 1, 2, \ldots, n_{jk}$ individuals within cohort j and period k;
$j = 1, 2, \ldots 9$ Birth cohorts;
$k = 1, 2, 3$ Survey years.

In this study, bivariate analysis is done using STATA 13 and Excel. For multivariate analysis SAS 9.4 is used.

3. Results

Table 1 depicts the prevalence of obesity for age in single years by place of residence and by caste group. The table represents the increasing prevalence of obesity with the increase in age of the women. The rural-urban differential is demonstrated in the table, where prevalence of obesity is higher among urban women than in rural women. About 29 percent of the urban women at age 49 are obese, whereas, only 13 percent of rural women are obese at age 49. Previous studies carried out in Indian settings have found that women in urban areas are more obese than women in rural areas (Garg et al., 2010; Pandey et al., 2013; Pradeepa et al., 2015; Tripathi et al., 2016; Yadav & Krishnan, 2008). Gouda and Prusty (2014) found that obesity increased with the increase in age of women. Agarwal (2002) stated that uncontrolled diet consumption and more sedentary life among urban women is the cause of obesity among them. He further stated that availability of modern household's amenities like car, television, and refrigerator is a cause of higher obesity levels.

The caste group is categorized into two different groups. In group

one, scheduled caste and scheduled tribes are taken. These two caste groups are socially backward in India. In group two, caste other than scheduled caste and scheduled tribes are coded. Caste group two primarily consists of Other Backward Classes (OBC) and other castes those are socially advantaged in comparison to castes in group one. The table depicts the higher prevalence of obesity for caste group two at all the ages. The women in caste group two, at any age, are more prone to obesity than women in caste group two. Our finding is in line with other studies. Agarwal (2002) in a study found that women belonging to SC and ST caste have lesser chances of obesity than the women in other caste groups. Gouda and Prusty (2014) also found that women in SC and ST caste group are less likely to be obese than women in OBC and other caste group. Zacharias and Vakulabharanam (2011), in a study carried out utilizing data from All India Debt and Investment Survey (AIDIS) conducted in 1991–92 and 2002–03, found that Scheduled Caste (SC) and Scheduled Tribe (ST) have lower wealth than Other Backward Class (OBC) in India. It is assumed that being the disadvantaged group in India, the caste group one (ST and SC caste group) has lesser access to the material goods. Hence, they have low levels of obesity as compared to caste group 2.

Table 2 gives the percentage distribution of Obese Indian Women by birth-cohort. The birth cohort 1968-72 has the highest percentage of obese women where around 1 in every four women was obese. Urban women and women belonging to caste group 2 have a higher percentage of obese women. The new cohort 1998–2002 has the lowest percentage of obese women. The difference in prevalence of obesity percentage between rural and urban as well as for caste group 1 and caste group 2 is high for the earlier cohorts. Women born in earlier cohorts are more obese than women born in the most recent birth cohorts. The plausible explanation is hidden in the year of birth cohorts. The women born in birth cohort 1948–52, 1953–57, 1958–62, and so on are the women in their 60s or 50s or 40s currently. At this age, physical activity decreases along with the metabolic rate (Gouda & Prusty, 2014), and this can cause women to gain excess weight. Further, women born in recent birth cohorts are in their 20s or 30s. At these ages, women are more health-conscious and involved in more physical activity, thus reducing the likelihood of obesity. The birth cohort analysis showed an acceleration of obesity for cohorts born in the mid-1960s, suggesting a change in obesity susceptibility for generations born after the 1960s. Diouf et al. (2010), utilizing data from four national surveys in 1997, 2000, 2003, and 2006, in their study carried out in France, found that cohorts born in the mid-1960s were more susceptible to become obese.

Table 3 shows the period-wise percentage of Obese Indian Women. As the time-period is increasing, the percentage of obese women is increasing. In 1998, the percentages of obese women were 10.37 percent, which has been increased to 20.13 in 2016. There is also a substantial difference in the percent of obese women between rural and

Table 3
Period wise percentage of Obese Indian Women: Total, place of residence and Caste Group.

Year	Total	Place of residence		Caste	
		Rural	Urban	Caste gp 1	Caste gp 2
1998	10.37	5.82	23.11	4.93	12.42
2006	12.35	7.27	23.17	7.05	14.31
2016	20.13	14.80	30.31	14.63	22.44

urban as well as caste group 1 and caste group 2.

Fig. 1 and Fig. 2 show the period RR and cohort RR of obesity among Indian women after controlling the other two effects, respectively. It is apparent from the result that obesity has increased over the years. For period measure, three time-period are taken for analysis viz. 1998, 2006, and 2016. The result found that the risk of being obese among women has increased from 0.58 in 1998 to 1.21 in 2016. For cohort measure, a total of 11 cohorts, are taken for analysis from 1948 to 52 to 1998–2002. The result found that women born in birth cohort 1973–77 are at less risk of suffering from obesity.

The estimated period relative risk for obesity among Indian women in Rural and Urban area are displayed in Fig. 3. Year 2006 is taken as the reference period for showing period Relative Risk (RR). The odds of having obesity has increased both in urban as well as in rural area from the period 2006 to 2016. The increase of odds from 2006 to 2016 are higher among women in the rural area than women in the urban area. By taking 2006 as the reference period for showing relative risk for period measure of obesity, it has been found that for the period 1998, the odds of being obese were higher among urban women but after two decades the odds changed drastically.

Fig. 4 shows the estimated cohort relative risk for obesity among Indian women in the rural and urban area. Birth cohort 1973–77 is taken as the reference cohort for estimating cohort relative risk. Cohort relative risk is higher among women in rural area than women in urban for all the cohort except one; 1978–82. However, with the reference cohort, the decline in odds of having obesity is steeper among women in rural areas than women in urban areas. With the reference cohort, the odds of having obesity among women in the rural area for the cohort 1948–52 is 1.44, whereas the odds decline to 1.20 for the rural women for cohort 1998–2002. For the women in the urban area, the relative risk for the initial cohort (1948–52) is 1.08, and a very small change has occurred in terms of relative risk for the latest cohort (1998–2002) in the study. The women born in around 1970 have the least risk of obesity in both the areas.

Fig. 5 shows the estimated period RR of obesity among Indian women by caste group. For the estimated period RR, the year 2006 is taken as the reference period. The period RR of obesity by caste is monotonically increasing from year 1998–2016, however, caste group 1
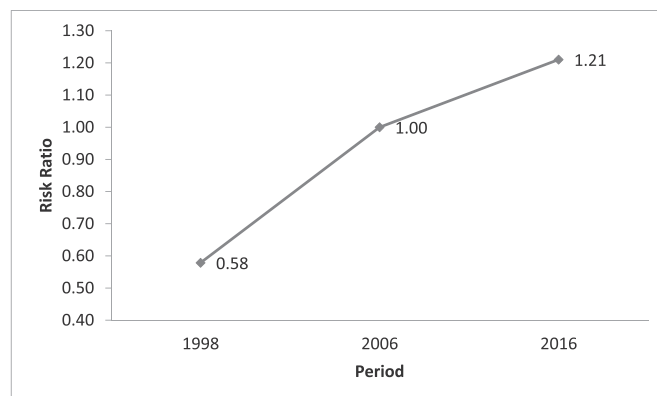
Table 2
Birth Cohort wise percentage of Obese Indian Women: Total, place of residence and Caste Group.

Birth cohort	Total	Place of residence		Caste	
		Rural	Urban	Caste group 1	Caste group 2
Birth Cohort 1948-52	19.66	12.08	37.60	9.21	22.99
Birth Cohort 1953-57	20.01	11.75	37.84	10.63	23.10
Birth Cohort 1958-62	19.82	11.90	37.00	11.08	22.76
Birth Cohort 1963-67	26.23	17.59	43.25	17.53	29.49
Birth Cohort 1968-72	27.57	19.31	43.24	19.10	30.79
Birth Cohort 1973-77	24.11	16.88	38.10	17.39	26.75
Birth Cohort 1978-82	22.86	16.45	35.54	16.77	25.28
Birth Cohort 1983-87	19.95	14.86	29.55	15.12	21.97
Birth Cohort 1988-92	13.22	9.98	19.58	10.11	14.57
Birth Cohort 1993-97	7.28	5.47	11.14	5.47	8.08
Birth Cohort 1998–2002	3.41	2.25	6.12	2.32	3.89

Fig. 1. Period RRs of Obesity among Indian Women.
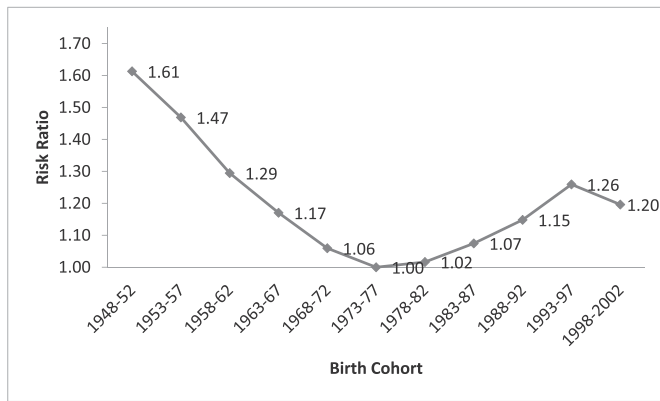
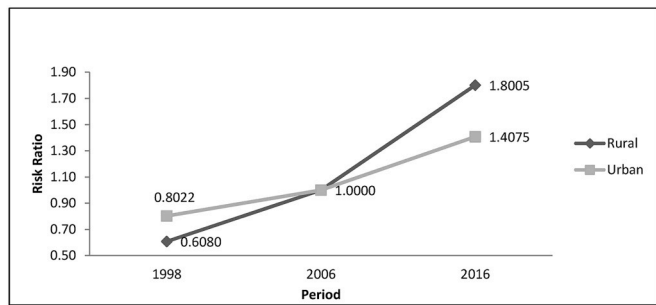**Fig. 2.** Cohort RRs of Obesity among Indian Women.

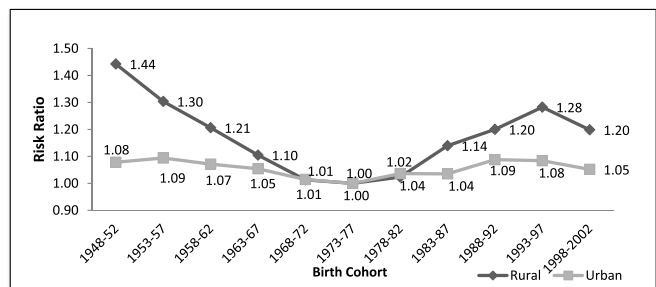**Fig. 3.** Period RRs of Obesity among Indian Women by place of residence.

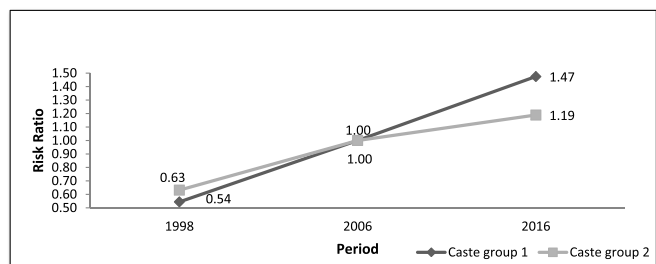**Fig. 4.** Cohort RRs of Obesity among Indian Women by place of residence.

Fig. 5. Period RRs of Obesity among Indian Women by caste group.

is at higher risk of being obese than caste group 2 for the period 2016. The risk of being obese was less during 1998 as compared to the reference period and increased drastically for the period 2016 among women in both the caste group. Initially, the RR was 0.54 for caste group 1, which increased to 1.47 in 2016, and RR for caste group 2 was 0.63 for the initial period and increased to 1.19 for the period 2016.

Fig. 6 shows the estimated cohort RR of obesity among Indian women by caste group. For estimated cohort RR, cohort 1973–77 is

taken as the reference period. RR for most of the cohort from 1948 to 52 to 1998–2002 is higher among the women for caste group 2. The cohorts on both sides of the reference cohort are having higher RR than the reference cohort f 1973–77. For caste group 1, the RR was 1.09 for the initial cohort, which is declined to 0.95 for the cohort 1998–2002. Similarly, for caste group 2, the RR was 1.23 for the initial cohort of 1948–52, which is declined to 1.02 for the recent cohort.

4. Discussion

This study is the first such study in the field of obesity that has investigated the long-term trends of urban-rural and caste differential in India. The study also canvassed the APC model through the age, period, and cohort effects. The age-period-cohort analysis is useful in understanding the temporal changes in the prevalence of obesity among women. We have used age-period-cohort analysis to better understand the prevalence of obesity among women in India. There are various studies which have investigated the effect of period and birth cohort on the prevalence of obesity (Jacobsen et al., 2001; Allman et al., 2008; Kwon et al., 2008; Koski, Jousilahti, & pietinen, 2001) but we could not find any such study in the Indian context.

The result found that for the period measure of obesity, there is an increase in obesity among women by place of residence and by caste group. However, as the birth cohort varies, the general trend for obesity decreases by caste group as well as by place of residence among women. This result suggests the existence of age and cohort effect for decreasing obesity.

Age effects represent the variation associated with different age groups brought about by physiological changes, accumulation of social experience, and role or status changes (Yang & Land, 2006). Age effects reflect the biological and social processes of aging internal to individuals and represent developmental changes across the life course. Our study shows as age increases the risk of obesity also increases. Previously published studies are consistent with our findings (Allman et al., 2008; Reither, Hauser, & Yang, 2009; Wilk, Maltby, & Cooke, 2017). Few studies found a U shape effect of age on Obesity (Allman et al., 2008; An & Xiang, 2016). A cohort refers to changes that characterise populations born at a particular point in time but are independent of the process of ageing (Blanchard, Bunker, & Wachs, 1977). While many studies across the globe show the increasing trend of obesity (Jaacks, Gordon-Larsen, Mayer-Davis, Adair, & Popkin, 2013; Wilk et al., 2017; Yamakita, Uchida, Kawamura, Homma, & Odagiri, 2014), this study shows the mix effect and found the obesity to be decreasing among the recent cohorts. This may be because of an increase in awareness about the obesity and demand for physical fitness in the wake of many correlated diseases threatening the livelihood and stipulating the out-of-pocket expenditure.

The period effect of obesity suggests that obesity is increasing from the period 1998 to 2016. The women in the rural area are more prone to suffer from obesity than women in the urban area during the period 2016, however, for the period 1998 urban women were more prone to
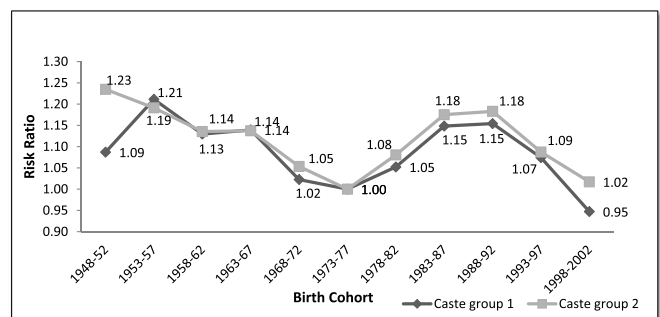

Fig. 6. Cohort RRs of Obesity among Indian Women by caste group.

have obesity than women in rural areas. The period effects represent variation over time that affects all age group simultaneously, which often results from shifts in social, cultural, or physical environments (Zheng, Yang, & Land, 2011). Shifts in social, cultural, economic or physical environments may, in turn, induce similar changes in the lives of all people at a given point of time and this is the possible explanation of the change of obesity prevalence among women by place of residence. The western culture has long lasted impact on the obesity in India because of the opening of several fast-food chains and stalls across the cities and even in the small towns of rural India. The rural population had a more rapid change in a period of 14 years and not immune because of increased mechanization of farming activity leading to reduced physical activity (Kalra, 2012).

5. Limitations of the study

There are several studies which have a basic limitation; the self-reporting of weight and height data (Allman et al., 2008). However, this study is free from such anomaly. The height and weight data are collected through proper tools by the investigator. For measuring obesity, Body Mass Index (BMI) is used as a tool. BMI gives no information about the body composition or location of the fat mass. BMI is known as the most commonly used tool for weight classification in obesity surveillance. However APC analysis helped in gaining better insight into the prevalence of obesity among women, but this study does not look into the potential reasons for obesity and only adds to the study related to the prevalence of obesity. The study is carried on women only thus neglected men. We focused on APC analysis by place of residence and caste, thus neglecting the other potential background characteristics for this study. Despite a few limitations, this study underscores the APC model that helps in understanding the cohort and period prevalence of obesity among women.

6. Implications of the study

As the study has pointed out the urban-rural and caste differential in the prevalence of obesity among Indian women, the government shall seek interventions to prevent the obesity.

Findings from this APC analysis have implications for public health policies. The APC analysis helps us to assess if there is an age group or birth cohort that should be targeted for interventions. The single year age analysis found that obesity is more prominent among urban women than in rural women, but cohort analysis found that for recent cohort obesity is more prominent among rural women than in urban women. This finding has implications from the policy point of view. The general view includes that urban women are more prone to suffer from obesity than women in rural areas (Yadav & Krishnan, 2008), but cohort analysis in the study found otherwise. This calls for the interventions related to obesity in rural areas also. There is a need to sensitise Information, Education, and Communication (IEC) activities related to obesity in rural areas also. In rural areas, the government shall provide routine health-care check-ups along with the obesity-focused education. In rural areas, the government shall also endorse advice related to physical exercise through local leaders.

7. Conclusions

In India, the caste differential and rural-urban differential are very prominent. This study is another brick cementing the space through the APC model in tune of caste and rural-urban differential of obesity among women. Cohort effect shows that obesity for recent cohort has narrowed down while period effect shows that rural women and women in upper caste are more prone to obesity. Though other studies have shown that women in the rural area are less prone to have obesity comparing to women in urban areas (Gouda & Prusty, 2014; Tripathy et al., 2016). There is a systematic difference in the upper caste and lower caste

people. The people of lower social strata in India belong to lower economic background, followed by much social exclusion, which makes them suffer from under-nutrition (Borooah, 2014). We have found that the recent cohorts have been gaining weight because of the change in the different living condition in recent past years showing the impact of obesity among them.

Ethical statement

Ethical approval

The data is available in public domain (International Institute for Population Sciences). The survey was approved by the International Institute for Population Sciences (IIPS). A consent form was also prepared and consent was taken from the respondent before undertaking the survey.

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Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2019.100507.

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