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Social epidemiology of excess weight and central adiposity in older Indians: analysis of Study on global AGEing and adult health (SAGE)

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ABSTRACT

Objectives: We aimed to estimate the prevalence of overweight and obesity, represented by extra body weight and abdominal circumference, among older Indians; and to characterise the social pattern of obesity and measure the magnitude of hypertension attributable to it.

Setting: A nationally representative sample of older Indians was selected from 6 Indian states, including Rajasthan, Uttar Pradesh, West Bengal, Assam, Maharashtra and Karnataka, as a part of the multicountry Study on global AGEing and adult health (SAGE).

Participants: Indians aged 50 years or more (n=7273) were included in the first wave of the SAGE (2010), which we used in our study.

Primary and secondary outcome measures: The primary outcome measures included excess weight (EW), defined by body mass index (BMI) >25 kg/m^2, and central adiposity (CA), defined by waist circumference >90 cm for men and >80 cm for women. The secondary outcome included hypertension, defined by systolic blood pressure >139 or diastolic blood pressure >79 mm Hg, or by those receiving antihypertensive medications.

Results: 14% of older Indians possessed EW, whereas 35% possessed CA; 50.9% of the wealthier third and 27.7% of the poorer two-thirds have CA; the proportions being 69.1% and 46.2%, respectively, in older women. Mostly wealth (adjusted OR for CA: 4.36 (3.23 to 5.95) and EW: 4.39 (3.49 to 5.53)), but also urban residence, privileged caste, higher education, white-collared occupation and female gender, were important determinants. One of 17 older Indians overall and 1 of 18 in the poorer 70% suffered from CA-driven hypertension, independent of BMI.

Conclusions: The problem of CA and its allied diseases is already substantial and expected to rise across all socioeconomic strata of older Indians, though currently, CA affects the privileged more than the underprivileged, in later life. Population-based promotion of appropriate lifestyles, with special emphasis on women, is required to counteract prosperity-driven obesity before it becomes too entrenched and expensive to uproot.

Strengths and limitations of this study

- The nationally representative sample of 50+ years old Indians allowed for country-wide prevalence estimates. It also allowed for nation-wide generalisability of association estimates.
- The large data set helped obtaining precise estimates.
- The cross-sectional nature of the data had the potential to partially affect the causal inferences, but to a negligible extent, given the strong plausibility of the associations and their temporal relationships.

INTRODUCTION

Developed nations around the world underwent demographic transitions during the last century, marked by declining mortality, increasing lifespan and diminishing fertility, leading to ageing of their populations.[1] This was inseparably linked to the epidemiological transition, marked by substantial decline of undernutrition, infection and childbirth-related diseases, and the rise of chronic lifestyles and age-related non-communicable illnesses such as cardiovascular diseases, diabetes, cancer and musculoskeletal disorders.[1] These transitions, mainly driven by progressive economic prosperity, also ushered in significant changes in lifestyle and nutritional practices in those societies. Consequently, rapidly growing body weight and abdominal girth beyond an optimum range, commonly referred to as 'obesity', in the literature (and also in this document hereafter), emerged as a major forerunning risk factor leading to a surge of chronic diseases of epidemic proportions, especially affecting their older citizens; similar trends are currently also being noticed in many middle-income countries, which have experienced economic transitions similar to the developed economies.[2–5]

Emerging economies, such as India, are likely to follow these transitions of the industrialised nations with a lag of a few decades,[4][5] as their economies prosper. It is already evident, from available reports, that obesity and its allied diseases are on the rise,[6–8] but the nexus of poverty, undernutrition and infectious diseases also remains a substantial health problem,[2][9] presenting a so-called 'double burden' to India.[10][11]

Some authors[12] have contended that attention needs to be paid to this surge of non-communicable diseases by the health policymakers of India, whereas others[12–15] have argued that the problem is still restricted to a minority of affluent Indians, and that the majority of Indians, who are underprivileged, are mostly spared. So, clamour for increased attention and public investment can inequitably divert scant health resources from the infectious and childbirth-related diseases of undernutrition, and poverty—the primary concerns affecting the overwhelming majority of underprivileged Indians.

Hence, it is important, in contemporaneous India, to study excess weight (EW) and abdominal circumference, critical forerunning risk factors for non-communicable diseases, and their social patterns, so that public policy can be appropriately informed for evidence-based equitable action. Otherwise, it may be difficult to avert an avoidable experience that many developed nations inherited from their transition, that is, a massive surge in obesity and related morbidity as well as mortality.[4][5]

Prevalence and social patterning of obesity has been sparingly studied in India; these studies have been mostly on children, adolescents[16][17] and young adults,[18][19] and also mostly in smaller samples restricted to regions or urban centres; but few studies have been conducted on older adults, among whom EW and adiposity have very important effects with regard to chronic age-related diseases and debilitating disabilities,[10][20][21] and who are also experiencing dwindling social support from the rapidly transitioning Indian family system, which traditionally remained a mainstay of support in later life. Also, the social determinants in the existing literature had mostly been studied using composite 'class' or 'status' variables while testing their association with obesity, and they had hardly been studied individually, which many feel can be critical for nation-specific social characterisation of obesity and its mitigation.[4] Moreover, the different forms of obesity, such as the generalised and abdominal variety, merit separate attention, especially for South Asians, who have the propensity to accumulate excess adipose tissue disproportionate to their weights.[22][23]

Therefore, we aimed at estimating the prevalence and social pattern of EW and abdominal obesity—among Indians aged 50 years and more—in a nationally-representative sample, and to then explore their relationship with individual social determinants. To put the problem into perspective, we aimed at measuring the magnitude of hypertension attributable to obesity; hypertension being one of the major outcomes of obesity and one of the classical proximal risk factors of cardiovascular disease.[24][25]

METHODS
Sample
The Study on global AGEing and adult health (SAGE) is an ongoing multicountry study on ageing, initiated by the WHO.[26] SAGE is aligned to similar prominent studies of ageing: Health and Retirement Survey (HRS)[27] of the USA, Study of Health, Ageing and Retirement (SHARE) of Europe, and English Longitudinal Study on Ageing (ELSA).[28] The first wave (2010) of the SAGE survey (n=7273) was conducted on a nationally representative probability sample of Indians aged 50 years or more, which we analysed. The sampled Indian states included Rajasthan, Uttar Pradesh, West Bengal, Assam, Maharashtra and Karnataka, which were selected using a multistage, stratified clustered sample design, the stratifying criteria being their geographic location and level of development and representative enough of the country-wide variation in geography and development.

Measurement
Body mass index (BMI) was calculated as measured weight (kg)/measured height $(m)^2$ and then categorised into an ordered variable: 0–18.5: underweight; 18.5–24.9: normal; and >25: EW. The cut-point for binary BMI was 25 kg/m^2; people with BMI >25 kg/m^2 were referred to as having EW, which includes obese as well as overweight groups of the conventionally used categories.[6] Central Adiposity (CA) was defined by waist circumference >90 cm and >80 cm among males and females, respectively.[29] The social determinants were: education, wealth, caste, occupation and area of residence (setting). Educational attainment was collapsed into three categories from the originally recorded seven—level 3: university graduate or postgraduate; level 2: secondary or higher secondary and level 1: primary education or never been to school. Household assets, a proxy for wealth, were originally data counted on a scale of 0–17 and then converted to quintile. Caste consisted of Scheduled Caste (SC—the most underprivileged under the Indian caste system), Scheduled Tribe (ST—indigenous tribal people), other (other than SC/ST) and no caste (not conforming to the Indian caste system). Occupation was categorised as a four-level variable—0: no paid work; 1: minimally skilled or subsistence; 2: semiskilled; 3: white-collared. area of residence was dichotomised (urban/rural). Tobacco users of smoked as well as smokeless forms were considered as never, previous and current users; with the same for alcohol users.

Hypertension (Y/N) was defined when the average of three measured systolic blood pressure tests exceeded 139 mm Hg and/or the average of three measured diastolic blood pressure tests exceeded 89 mm Hg

and/or the individual received antihypertensive medications.[25]

Statistical analysis

Initially, prevalence of EW and CA among the population was determined. Distribution of three-level BMI (underweight, normal and EW) across its various categorical risk factors was described using contingency tables, and differences were tested using χ^2 test.

The strengths of association between binary BMI (EW: Y/N) and each individual social determinant were estimated using logistic regression, initially minimally adjusted for age and gender; followed by a fully adjusted model that additionally included all social determinants such as education, assets, caste, occupation and place of residence, and also tobacco-use status as a confounder, to estimate their independent effects. Standardised regression coefficients were calculated to compare the effect sizes, as they were measured in different scales. Similar statistical methods were repeated with CA as binary outcome. Interaction between risk factors and gender was tested in the models.

The Population Attributable Fraction (PAF) of CA (both BMI adjusted and BMI unadjusted) was calculated in relation to the prevalence of hypertension in the population and subpopulations, using the *aflogit*[30] package of STATA (V.12.1) (StataCorp, College Station, Texas, USA), following post-Poisson regression models; with the models also controlling for the effects of smoking and alcohol use. For other analyses R software (V.3.1.1)[31] was used.

RESULTS

Overall, 14% (13.69–14.31%) of Indians aged 50 years and above (n=912) have EW, whereas 34.5% (33.72–35.28%) (n=2255) have CA (table 1). Prevalence of underweight was 35%. Of EWs, 84% possessed CA, whereas only 43% CAs possessed EW (figure 1). The prevalence of CA was consistently higher than EW across all social determinant groups, as shown below.

Prevalence of EW (table 2) and CA (table 3) was nearly twice in older Indian women than in men (EW: 18% women vs 10.5% men and CA: 35.5% women vs 19.4% men, p<0.0001). EW and CA were more prevalent among the highly educated (EW: 28.2% highest educated vs 11.9% lowest educated, CA: 48% highest vs 33% lowest educated (p<0.0001); a consistent gradient was apparent across the three categories of education. Prevalence of EW in urban and rural areas was 25.5% and 10.3%, respectively (p<0.0001); comparable to the distribution of CA (51.4% and 29.2%, respectively, p<0.0001). Both EW and CA had significantly different distribution across occupational group; white-collared category having 26.1% EW and 42.8% CA, compared to 8.9% and 26.1% of EW and CA, respectively, among unskilled/subsistence workers (p<0.0001). Almost 30% in the top affluent quintile possessed EW compared to

Table 1 Distribution of demographic characteristics, social determinants, excess weight and central adiposity in Indians aged 50 years and older in SAGE sample (n=7273) (2007–2010)

	Number	Per cent
Age (years)		
50–59	3234	44
60–80	3665	50
≥80	374	5
Gender		
Male	3682	51
Female	3591	49
Caste		
No caste or tribe	1132	17
Other	3979	60
Scheduled Caste	1102	17
Scheduled Tribe	400	6
Occupation		
No paid occupation	1863	28
Traditional subsistence or unskilled	3428	52
Semi-skilled	914	14
Skilled or white-collar	425	6
Education		
Illiterate or up to primary	5105	77
Secondary	1213	18
Higher secondary and higher	328	5
Quintiles of asset		
Lowest (0–4)	1464	20
Lower middle (4–6)	1760	24
Middle (6–8)	1717	24
Upper middle (8–10)	1265	17
Highest (10–16)	1049	14
Area of residence		
Urban	1899	26
Rural	5374	74
BMI: kg/m^2		
Underweight (<18.5)	2270	35
Normal (18.5–24.9)	3246	50
Excess weight (≥25)	912	14
CA		
No	4209	65
Yes	2255	35

For the following variables the number of observations with missing values—BMI: 845 kg/m^2; CA: 809; caste: 660; education: 627; assets quintile: 18; occupation: 643.
BMI, body mass index; CA, central adiposity; SAGE, Study on global AGEing and adult health.

5% among the poorest quintile, (p<0.0001). The corresponding prevalence of CA was 50% and 13% among the top and bottom groups, respectively (P<0.0001). A clear trend was evident across wealth quintiles. EW was significantly more prevalent among the population that had 'no' caste (16.8%) or belonged to 'other' caste (16.3%), than ST (7.5%) and SC (6.5%) (p<0.0001). The corresponding prevalence of CA was 43.9%, 37%, 21.6% and 23.6%, respectively (p<0.0001).

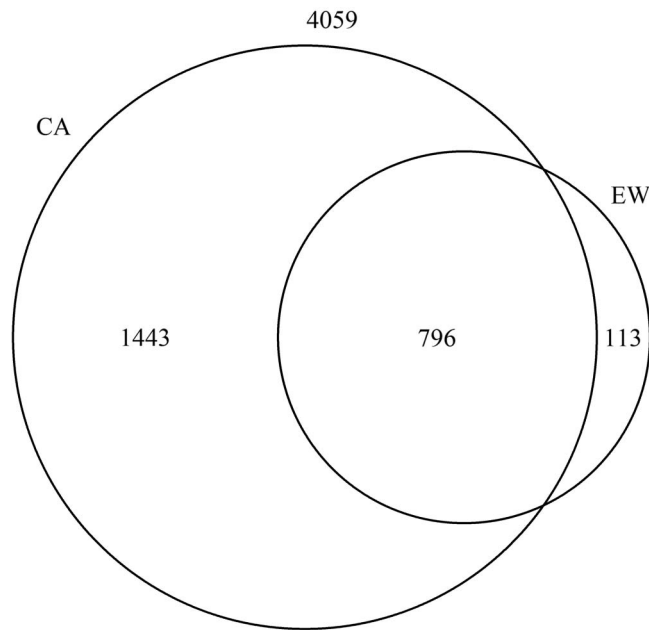In the minimally adjusted models, greater household wealth, urban residence, higher education, privileged

Figure 1 The prevalence of excess weight and central adiposity among older Indians aged 50 years or more.

caste and white-collared jobs, and also female gender, were all associated with greater odds of EW and CA in older Indians (tables 2 and 3). In the fully adjusted model, effect of education attenuated to almost null as attenuation of similar magnitude was also evident for occupation; whereas the effects of caste and setting were partially attenuated. The estimate of wealth also underwent partial attenuation, nevertheless, its independent effect was sizeable and eventually was the strongest among all the social determinants, as was evident from their standardised coefficients (see online supplementary table S1); OR for highest versus lowest quintile for EW 4.36 (3.23 to 5.95) and CA 4.39 (3.49 to 5.53). Tobacco use had negative association with both EW and CA. The gender risk factor interaction terms were not significant except for caste when CA was the outcome; upper caste women being significantly more likely to be affected with CA than upper caste men.

Approximately 40% of Indians (50+) suffered from hypertension. The tobacco and alcohol-adjusted OR of CA was 1.99 (1.78 to 2.23); after adjustment with BMI it was 1.63 (1.44 to 1.86). The overall BMI-unadjusted and BMI-adjusted PAF of hypertension, attributable to CA, was 14% (126% to 16.2%) and 11% (9.0% to 13.0%), respectively. The corresponding unadjusted and adjusted PAF in the lower 70% wealth bracket (hypertension: 36%) was 15% and 12%, respectively, and that among the wealthier 30% group (hypertension: 44%) was 11% and 8%, respectively. Among females (hypertension: 42%), the probability of hypertension attributable to CA was as high as 13% (BMI unadjusted) and 12% (BMI adjusted) (see online supplementary table S2).

DISCUSSION

Our study showed 14% older Indians had EW, while underweight was 2.5 times more prevalent. However, more than one of three older Indians possessed CA; and CA is considered an equally if not more important independent risk factor of cardiometabolic diseases.[22] This indicates that accumulation of additional weight in later life among Indians was yet to assume substantial proportions compared to their undernutrition-related lack of appropriate body mass, albeit currently, the problem of abdominal fat accumulation manifested as CA was definitely not negligible among these older adults. This was even more significant because a sizeable proportion of these CA-affected older Indians had normal BMI, indicating abdominal girth being a more sensitive guide than weight-based metric, to measure obesity-related risk among older Indians.

What also becomes more significant from the public policy perspective is that not only one out of two older Indians in the top 30% wealth bracket has CA, but also, one of four among the less wealthy 70% possesses it. Even more remarkable is the distribution among older Indian women, every second of whom is affected with CA, and where the wealth gradient for CA is narrower; 69% among the wealthier 30% and 46% in the less wealthy 70% of older women have CA.

Hence, perhaps for the first time, our study, from a nationally-representative sample of older Indians, illustrated that although a distinct positive economic gradient exists, obesity, especially the abdominal variety, is definitely no longer only restricted to affluent older Indians. The 'poorer 75%' are also substantially affected, large sections of whom are believed to be still surviving on an average of US$2 per day.[32]

Every 17th Indian aged 50 years or over suffered from CA-related hypertension, a fraction of which could be perhaps apportioned to their high BMI; but after accounting for BMI, 1 of 22 had prevalent hypertension exclusively attributable to CA. In the lower 70% wealth bracket, the BMI-adjusted and BMI-unadjusted portions of hypertension attributable to CA were of comparable magnitude. It must be considered that these benefits were estimated in terms of only one obesity-related outcome, hypertension, whereas far greater benefits may be achieved in terms of other obesity-driven conditions such as diabetes, cardiovascular disease and musculoskeletal disorders, which could not be evaluated here due to lack of their objective measures in the SAGE sample. This indicated that prevention and control of CA, which will also largely mitigate the EW problem, will benefit many older Indians across all socioeconomic strata.

Subramanian et al[33] apprehended that any significant resource allocation to the control of non-communicable diseases in the current Indian context would deprive the poor, causing diversion of scant public health resources from control of infectious and childbirth-related diseases, which affect the vast majority of Indians, who are predominantly poor. They concluded that the burden of

Table 2 Association of social determinants with excess weight in Indians aged 50 years and older in SAGE sample

	Excess weight (BMI $\geq$25 kg/m^2) n (%)	Minimally adjusted* OR (95% CI)	Fully adjusted† OR (95% CI)
Age (years)			
50–59	513 (18)	0.97 (0.96 to 0.98)	0.97 (0.96 to 0.98)
60–80	374 (12)		
>80	25 (9)		
Gender			
Male	341 (10.5)	1	1
Female	571 (18)	1.82 (1.57 to 2.12)	1.67 (1.34 to 2.07)
Tobacco user			
Never used	592 (19.6)	1	1
Ever used	63 (12)	0.71 (0.53 to 0.95)	0.82 (0.60 to 1.10)
Current user	257 (8.9)	0.46 (0.39 to 0.54)	0.67 (0.56 to 0.80)
Caste			
Scheduled Caste	70 (6.5)	1	1
Scheduled Tribe	29 (7.5)	1.11 (0.69 to 1.73)	1.27 (0.79 to 2.01)
Other	627 (16.3)	2.83 (2.20 to 3.70)	1.83 (1.40 to 2.43)
No caste or tribe	183 (16.8)	2.94 (2.20 to 3.96)	1.95 (1.44 to 2.66)
Occupation			
Traditional subsistence or unskilled	296 (8.9)	1	1
Semiskilled	136 (15.4)	2.01 (1.60 to 2.50)	1.21 (0.95 to 1.54)
Skilled or white-collar	107 (26.1)	4.09 (3.15 to 5.28)	1.77 (1.31 to 2.37)
No paid occupation	370 (20.8)	2.07 (1.72 to 2.50)	1.36 (1.11 to 1.66)
Education			
Illiterate or up to primary	584 (11.9)	1	1
Secondary	239 (20.2)	2.63 (2.18 to 3.16)	1.26 (1.02 to 1.55)
Higher secondary and higher	89 (28.2)	4.37 (3.30 to 5.76)	1.17 (0.84 to 1.62)
Quintiles of asset			
Lowest (0–4)	70 (5)	1	1
Lower middle (4–6)	134 (9)	1.70 (1.26 to 2.30)	1.42 (1.04 to 1.94)
Middle (6–8)	203 (13)	2.74 (2.07 to 3.66)	2.01 (1.51 to 2.72)
Upper middle (8–10)	234 (21)	4.84 (3.67 to 6.46)	2.83 (2.10 to 3.84)
Highest (10–16)	270 (30)	8.02 (6.08 to 10.71)	4.36 (3.23 to 5.95)
Area of residence			
Rural	494 (10.3)	1	1
Urban	418 (25.5)	2.97 (2.57 to 3.44)	1.83 (1.55 to 2.16)

*Adjusted for age and gender.
†Adjusted for age, gender, tobacco, caste, occupation, education, assets and area of residence.
BMI, body mass index; SAGE, Study on global AGEing and adult health.

chronic ailments and their risk factors is significant among the poor but> largely restricted to the minority elite in India. Opponents argued[12–15] that there are signs of 'reversal' of this positive socioeconomic gradient for chronic age-related diseases, claiming the poor are now more affected by them; hence their demand for significant public investment into non-communicable diseases.[12] Our study, reflecting the national situation among older Indians as opposed to regional or predominantly urban results, suggests a cautious middle ground[14] in this 'problematic discourse.'[33] Although a positive socioeconomic gradient for obesity was strongly evident among the current country-wide older population, the significant prevalence of CA, even among the older underprivileged and, especially, women, cannot be ignored. This certainly calls for a prompt population-based policy response against obesity, especially with an

eye towards its older population, which may enable them to lead a relatively morbidity-free and disability-free productive later life. Otherwise, delay in action can make the obesity problem too deeply entrenched and resource intensive to uproot, and, even worse, starts inequitably affecting the lower socioeconomic sections more, as has happened in many developed nations, the so-called 'reversal' of their socioeconomic gradient.[4] However, all efforts should be made to preserve public investment for the 'unfinished business' of undernutrition and poverty-related diseases, which still affects a large section of the population, especially when they are young and in their reproductive ages.

From the crude and independent effects of various social determinants, and using a priori knowledge, we drew a causal link among social determinants leading to CA[34] (figure 2). Calorie overconsumption and calorie

Table 3 Association of social determinants with Central Adiposity in Indians aged 50 years and older in SAGE sample

	Participants with central adiposity n (%)	Minimally adjusted* OR (95% CI)	Fully adjusted† OR (95% CI)
Age (years)			
50–59	890 (30)	0.98 (0.977 to 0.98)	0.98 (0.977 to 0.99)
60–80	815 (25)		
>80	61 (20)		
Gender			
Male	633 (19.4)	1	1
Female	1622 (50.8)	4.23 (3.79 to 4.73)	2.52 (2.14 to 2.99)
Tobacco user			
Never used	1099 (36.1)	1	1
Ever used	129 (24.3)	0.79 (0.63 to 0.99)	0.90 (0.71 to 1.13)
Current user	537 (18.6)	0.50 (0.44 to 0.57)	0.69 (0.60 to 0.79)
Caste			
Scheduled Caste	255 (23.6)	1	1
Scheduled Tribe	85 (21.6)	0.88 (0.65 to 1.17)	1.26 (0.90 to 1.74)
Other	1427 (37)	2.04 (1.74 to 2.41)	1.71 (1.41 to 2.09)
No caste or tribe	483 (43.9)	2.73 (2.24 to 3.32)	2.14 (1.71 to 2.68)
Occupation			
Traditional subsistence or unskilled	873 (26.1)	1	1
Semiskilled	306 (34.5)	2.10 (1.76 to 2.49)	1.32 (1.09 to 1.60)
Skilled or white-collar	177 (42.8)	3.39 (2.70 to 4.26)	1.50 (1.16 to 1.94)
No paid occupation	893 (49.7)	1.31 (1.14 to 1.50)	1.02 (0.87 to 1.19)
Education			
Illiterate or up to primary	1660 (33.5)	1	1
Secondary	441 (37.3)	2.45 (2.09 to 2.87)	1.22 (1.02 to 1.45)
Higher secondary and higher	154 (48.3)	4.42 (3.43 to 5.70)	1.30 (0.97 to 1.74)
Quintiles of asset			
Lowest (0–4)	226 (20.1)	1	1
Lower middle (4–6)	440 (28)	1.70 (1.42 to 2.05)	1.64 (1.33 to 2.02)
Middle (6–8 assets)	520 (33.7)	2.28 (1.91 to 2.74)	1.97 (1.60 to 2.42)
Upper middle (8–10)	519 (46.5)	4.28 (3.54 to 5.19)	2.73 (2.19 to 3.41)
Highest (10–16)	507 (56.3)	6.73 (5.49 to 8.26)	4.39 (3.49 to 5.53)
Area of residence			
Rural	1410 (29.2)	1	1
Urban	845 (51.4)	2.72 (2.41 to 3.08)	1.77 (1.54 to 2.03)

*Adjusted for age and gender.
†Adjusted for age, gender, tobacco, caste, occupation, education, assets and area of residence.
SAGE, Study on global AGEing and adult health.

underexpenditure were included in the causal diagram as the most proximate factors leading to CA, though these lifestyle characteristics were not objectively measured in the sample. The hypothesised causal links were empirically validated post hoc using Bayesian Network Learning ('bnlearn' package in R).[35] The empirical results almost matched the a priori assumptions, however, the arc between caste and education was missing in the Bayesian Network (see online supplementary figure S1).

Our result describes wealth as the major driver of obesity having largest standardised coefficients in the fully adjusted model. Wealth-driven overconsumption has flourished within the culture of chronic food deprivation that Indian society had experienced for centuries; hence any form of socioeconomic advantage was utilised for accumulating extra calories. Also, socioeconomic prosperity was perhaps related to increased sedentariness. Privileged occupation and caste, major sources of inequity in Indian society, were positively associated with obesity, largely through increased wealth and sedentariness. Association between urban living and obesity was partly explained by clustering of obesogenic factors such as wealth, education and white-collared occupation in the cities, and partly mediated by the direct effect of a less active urban lifestyle with regard to commuting and daily chores.

Despite its effect attenuating substantially after adjustment for wealth and occupation, through which it is believed to affect obesity, educational achievement was yet to caste any direct protective antiobesity effect among older Indians, unlike in many middle and high-income countries,[4] where cognitive and information processing skills acquired from education are believed to
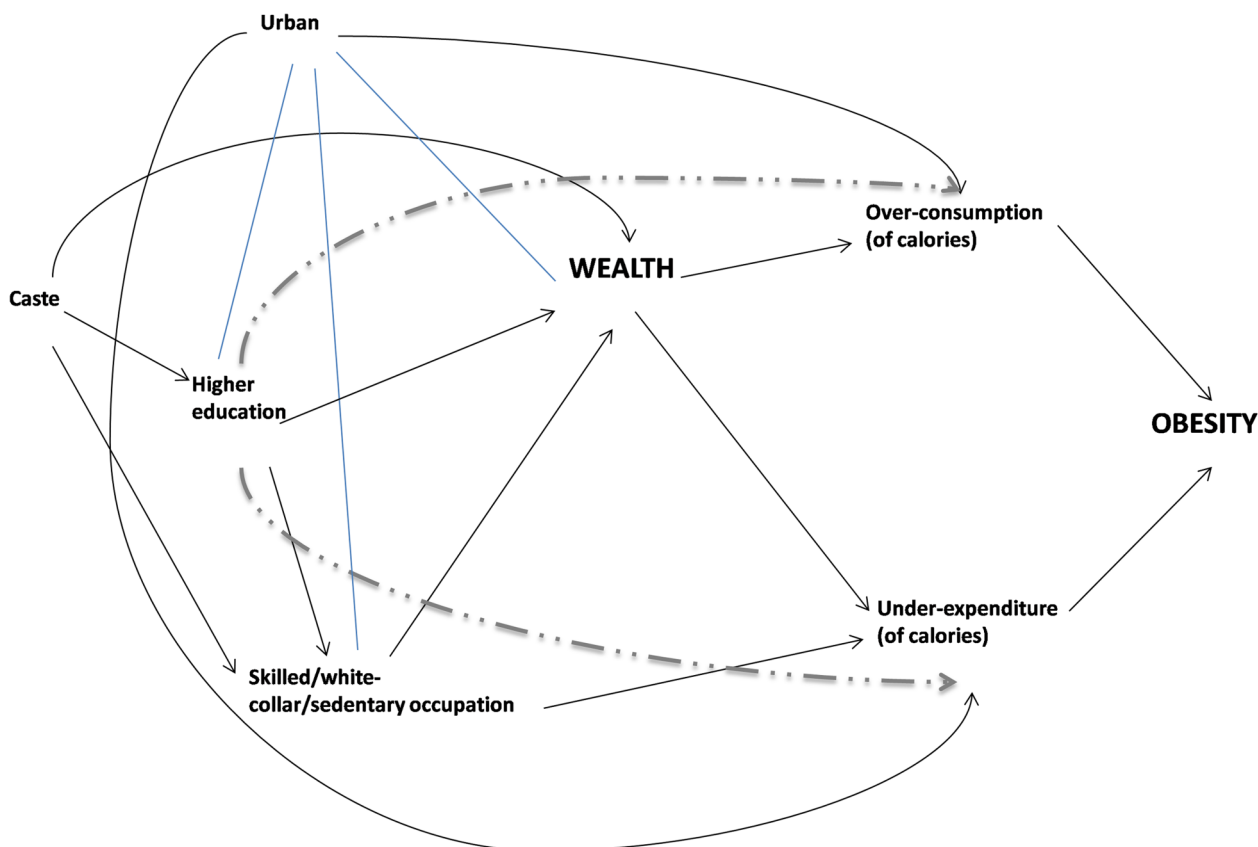
Figure 2 The association between obesity and its various social determinants. The solid arrows denote causal relationship; the lines without arrows denote association; the dotted arrows denote suggested protective pathways which should be utilised as a preventative antiobesity strategy.

help their citizens to negotiate the wealth-related over-consumption and underexpenditure of calories, marking the gradient 'reversal' in those societies.

Despite the entrenched, or also perhaps growing, wealth inequity in Indian society,[36] a large number of underprivileged Indians—the 'lower 75%'[33]—have undeniably benefitted from the post-nineties' economic growth; and, furthermore, the current economic environment of India will continue to increase the prosperity of many more Indians across all socioeconomic strata. Simultaneously, both calorie overconsumption and underexpenditure are likely to become more affordable and achievable to everyone through greater availability of calorie-dense industrially produced food at relatively cheaper prices, notwithstanding food inflation in the country; increasing automation of jobs and domestic chores even in the low-earning segment; and increased rate of urbanisation. This will accelerate the obesity burden in all strata of Indian society, though the 'reversal' of the positive socioeconomic gradient in the recent foreseeable future seems unlikely; this will only happen when the country crosses a certain economic developmental threshold,[4 5] enabling the protective effect of education to 'kick in'.

From the policy perspective, this growing obesity problem, affecting all societal strata, has to be confronted through investment in population-based public health initiatives, among which large-scale promotion for adoption, at all stages of life, of appropriate lifestyle, a component that is prominently missing from the current rudimentary Indian national programme for non-communicable diseases, should be prioritised.[37] The societal aspiration for 'big size' and 'sedentariness' as signs of accomplishment[38] may also have to be counteracted. Legislation against the food industry or development of active lifestyle-enabling urban infrastructure may follow. However, the first and foremost step would be to put obesity into the centre stage of the national sociopolitical discourse, so that Indians recognise it as a serious problem, as has been done recently with similar 'big ticket' societal issues in India, such as sanitation and toilet use.

In terms of future policy and research implications, targeted emphasis must be laid on Indian women, as they have substantially greater independent risk of obesity, which renders them more vulnerable to its dire health outcomes, especially disability,[39] which may hinder their independent community living in later life.

Our study's limitation is its cross-sectional design, perhaps partly compromising our causal inferences. However, the described causal relations are so plausible that such bias, if any, is perhaps negligible. Also, among

older Indians, the role of age-related frailty inflating the underweight segment and obscuring some of the obesity-social determinant relationship, cannot be entirely ruled out. Detailed and objective measures of dietary habits including salt consumption and physical activity were not collected in the SAGE sample; these measures could have provided us with an opportunity to explore the role of these mediators in the pathway to excess weight, obesity and hypertension in this population.

The strength of our study is the India-wide generalisability, precise estimates and reliable measures[40] from the large nationally representative SAGE sample; also emulating ELSA, SHARE and HRS designs, which helped to generate valuable chronic disease-related evidence with policy implications for the older population in those countries.

To conclude, our study has shown, for the first time, to the best of our knowledge, that obesity, mainly the abdominal variety, has a country-wide presence of significant proportion in the Indian population of individuals aged 50 years and older; and although the richer are more affected, the problem is also substantial in the lower socioeconomic stratum. Wealth being its strongest social driver and with ongoing economic growth of India, obesity is likely to increase rapidly in all the socio-economic segments, unless acted on promptly, which should entail putting obesity into the national socio-political discourse and combating it through primordial population-based preventative actions.

REFERENCES

1. Mazzocchetti A, Caranci N, Addis A. [Population ageing and health implication. Thinking time trends in Emilia-Romagna Region]. *Recenti Prog Med* 2014;105:191–7.
2. Reid CM, Thrift AG. Hypertension 2020: confronting tomorrow's problem today. *Clin Exp Pharmacol Physiol* 2005;32:374–6.
3. Pérez Rodrigo C. Current mapping of obesity. *Nutr Hosp* 2013;28 (Suppl 5):21–31.
4. Dinsa GD, Goryakin Y, Fumagalli E, *et al*. Obesity and socioeconomic status in developing countries: a systematic review. *Obes Rev* 2012;13:1067–79.
5. Monteiro CA, Moura EC, Conde WL, *et al*. Socioeconomic status and obesity in adult populations of developing countries: a review. *Bull World Health Organ* 2004;82:940–6.
6. Shukla A, Kumar K, Singh A. Association between obesity and selected morbidities: a study of BRICS countries. *PLoS ONE* 2014;9:e94433.
7. Manton KG. The global impact of noncommunicable diseases: estimates and projections. *World Health Stat Q* 1988;41:255–66. http://www.ncbi.nlm.nih.gov/pubmed/3232413 (accessed 17 Sep 2014).
8. Asia Pacific Cohort Studies Collaboration. The burden of overweight and obesity in the Asia-Pacific region. *Obes Rev* 2007;8:191–6.
9. Wang Y, Chen HJ, Shaikh S, *et al*. Is obesity becoming a public health problem in India? Examine the shift from under- to overnutrition problems over time. *Obes Rev* 2009;10:456–74.
10. Yadav S, Arokiasamy P. Understanding epidemiological transition in India. *Glob Health Action* 2014;7:23248. http://www.ncbi.nlm.nih.gov/pubmed/24848651 (accessed 18 Jul 2014).
11. Pandian JD, Srikanth V, Read SJ, *et al*. Poverty and stroke in India: a time to act. *Stroke* 2007;38:3063–9.
12. Prabhakaran D, Jeemon P, Reddy KS. Commentary: Poverty and cardiovascular disease in India: do we need more evidence for action? *Int J Epidemiol* 2013;42:1431–5.
13. Narayan KM, Ali MK. Commentary: Shielding against a future inferno: the not-so-problematic discourse on socioeconomic status and cardiovascular health in India. *Int J Epidemiol* 2013;42:1426–9.
14. Jones-Smith JC. Commentary: Jumping the gun or asleep at the switch: is there a middle ground? *Int J Epidemiol* 2013;42:1435–7.
15. Stringhini S, Bovet P. Commentary: The social transition of cardiovascular disease in low- and middle-income countries: wait and see is not an option. *Int J Epidemiol* 2013;42:1429–31.
16. Khadilkar VV, Khadilkar AV, Cole TJ, *et al*. Overweight and obesity prevalence and body mass index trends in Indian children. *Int J Pediatr Obes* 2011;6:e216–24.
17. Saha AK, Sarkar N, Chatterjee T. Health consequences of childhood obesity. *Indian J Pediatr* 2011;78:1349–55.
18. Kulkarni P, Nagendra, Ashok NC, *et al*. World health organization-body mass index for age criteria as a tool for prediction of childhood and adolescent morbidity: a novel approach in southern karnataka, India. *Int J Prev Med* 2014;5:695–702. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4085921&tool=pmcentrez&rendertype=abstract (accessed 18 Jul 2014).
19. Shah T, Purohit G, Nair SP, *et al*. Assessment of obesity, overweight and its association with the fast food consumption in medical students. *J Clin Diagn Res* 2014;8:CC05–7.
20. Samper-Ternent R, Al Snih S. Obesity in older adults: epidemiology and implications for disability and disease. *Rev Clin Gerontol* 2012;22:10–34. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3278274&tool=pmcentrez&rendertype=abstract (accessed 16 Jul 2014).
21. Zamboni M, Mazzali G, Zoico E, *et al*. Health consequences of obesity in the elderly: a review of four unresolved questions. *Int J Obes (Lond)* 2005;29:1011–29.
22. Sniderman AD, Bhopal R, Prabhakaran D, *et al*. Why might South Asians be so susceptible to central obesity and its atherogenic consequences? The adipose tissue overflow hypothesis. *Int J Epidemiol* 2007;36:220–5.
23. Wells JC. Commentary: Why are South Asians susceptible to central obesity?—the El Niño hypothesis. *Int J Epidemiol* 2007;36:226–7.
24. O'Donnell CJ, Elosua R. Cardiovascular risk factors. insights from Framingham Heart Study. *Rev Esp Cardiol* 2008;61:299–310.
25. Basu S, Millett C. Social epidemiology of hypertension in middle-income countries: determinants of prevalence, diagnosis, treatment, and control in the WHO SAGE study. *Hypertension* 2013;62:18–26.
26. Kowal P, Chatterji S, Naidoo N, *et al*. Data resource profile: the World Health Organization Study on global AGEing and adult health (SAGE). *Int J Epidemiol* 2012;41:1639–49.
27. Connor JH. *Technical Description of the Health and Retirement Survey Sample Design*. 1995. hrsonline.isr.umich.edu/sitedocs/userg/HRSSAMP.pdf.
28. Steptoe A, Breeze E, Banks J, *et al*. Cohort profile: the English Longitudinal Study of Ageing. *Int J Epidemiol* 2013;42:1640–8.
29. World Health Organization. Waist circumference and waist-hip ratio. Report of a WHO expert consultation. Geneva: 2011.

30. Brady AR. Adjusted population attributable fractions from logistic regression. *Stata Tech Bull* 1998;42:8–12.
31. R Development Core Team R. R: A Language and Environment for Statistical Computing. *R Found Stat Comput* 2011;1:409.
32. No Title. http://data.worldbank.org/indicator/SI.POV.2DAY/countries?page=1
33. Subramanian SV, Corsi DJ, Subramanyam MA, *et al*. Jumping the gun: the problematic discourse on socioeconomic status and cardiovascular health in India. *Int J Epidemiol* 2013;42:1410–26.
34. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. *Epidemiology* 1999;10:37–48.
35. Thornley S. Using Directed Acyclic Graphs for Investigating Causal Paths for Cardiovascular Disease. *J Biometrics Biostatistics* 2013;4:182.
36. Subramanian SV, Subramanyam MA, Corsi DJ, *et al*. Rejoinder: Need for a data-driven discussion on the socioeconomic patterning of cardiovascular health in India. *Int J Epidemiol* 2013;42:1438–43.
37. No title. http://pib.nic.in/newsite/efeatures.aspx?relid=76249
38. Case A, Menendez A. Sex differences in obesity rates in poor countries: Evidence from South Africa. *Econ Hum Biol* 2009;7:271–82.
39. Hosseinpoor AR, Williams JS, Jann B, *et al*. Social determinants of sex differences in disability among older adults: a multi-country decomposition analysis using the World Health Survey. *Int J Equity Health* 2012;11:52.
40. Kowal P, Biritwum R, Haldia K, *et al*. SAGE Working Paper No. 2. WHO Study on global AGEing and adult health (SAGE): Summary result of apilot in three countries. Geneva: 2012.