BMJ Open

# Social determinants of diabesity and its association with multimorbidity among older adults in India: a population-based cross-sectional study

Abhinav Sinha ,[1] Parul Puri ,[2] Sanghamitra Pati[1]

**To cite:** Sinha A, Puri P, Pati S. Social determinants of diabesity and its association with multimorbidity among older adults in India: a population-based cross-sectional study. *BMJ Open* 2022;**12**:e061154. doi:10.1136/bmjopen-2022-061154

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-061154).

AS and PP contributed equally.

Received 18 January 2022
Accepted 15 September 2022



[1]ICMR-Regional Medical Research Centre Bhubaneswar, Bhubaneswar, Odisha, India
[2]Department of Survey Research and Data Analytics, International Institute for Population Sciences, Mumbai, Maharashtra, India

**Correspondence to**
Dr Sanghamitra Pati;
drsanghamitra12@gmail.com

## ABSTRACT

**Objectives** India, a major contributor to the global diabetes burden, is witnessing a simultaneous epidemic of obesity leading to rise in diabesity. Diabesity, the coexistence of diabetes and obesity in an individual, has emerged as a risk factor for other morbidities and hence, multimorbidity. Although diabesity has long been recognised, still, there is a poor understanding of its social determinants in India, necessary for its control. We aimed to estimate and compare the prevalence and identify social determinants of obesity, diabetes and diabesity; explore their association with other selected non-communicable diseases (NCDs) multimorbidity; and assess its outcomes among adults aged ≥45 years.

**Design and setting** We undertook an observational analyses employing nationally representative data from Longitudinal Ageing Study in India, 2017–2018.

**Participants** This study was conducted among n=59 073 respondents.

**Outcome measures** Descriptive analysis was conducted among n=59 073 respondents to determine prevalence of diabetes, obesity and diabesity. The social determinants were assessed using multinomial regression, reported as adjusted relative risk ratio (RRR). A multiple correspondence analysis generated life satisfaction.

**Results** The prevalence of obesity, diabetes, and diabesity was 21.2%, 6%, and 5.8%, respectively. We identified women (RRR: 2.16 (1.72 to 2.71)), urban residents (RRR: 3.73 (3.07 to 4.54)) and affluent groups (RRR: 3.60 (2.46 to 4.58)) had a higher likelihood of having diabesity. The association with various NCDs showed multimorbidity to be akin to the diabesity group. We observed inferior life satisfaction and significantly higher healthcare utilisation among participants with diabesity as compared with other two groups.

**Conclusion** Increased obesity prevalence has led to the rise in diabesity in India. Additionally, the level of multimorbidity in this group cannot be overlooked. Rather than focusing on individual conditions, an in toto approach to multimorbidity is warranted.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Findings are based on a nationally representative data from Longitudinal Ageing Study in India, wave 1.
⇒ It is limited by self-reported conditions being taken into consideration.
⇒ Being a cross-sectional survey, it does not establish causality.

## INTRODUCTION

The WHO, through its global action plan to prevent and control non-communicable diseases (NCDs), focuses on four major chronic diseases: cardiovascular diseases, cancer, diabetes and respiratory diseases.[1] India, a low/middle-income country, contributes to a significant part of the global diabetes burden.[2 3] According to the Global Burden of Disease (GBD) 2016, the age-standardised diabetes prevalence rose by 29.7% (95% uncertainty interval: 26.5–32.6) in India from 1990 to 2016.[4] NCDs can be attributed to behavioural, dietary, environmental and metabolic risk factors which have attracted substantial global attention.[5] Additionally, socioeconomic disparities, including childhood inequalities, also lead to NCDs.[6]

Obesity, an individual NCD, was identified as the most crucial risk factor for diabetes in India.[7 8] A study conducted by GBD collaborators stated that for every 100 overweight adults (≥20 years and above), there were 38 adults (95% uncertainty interval: 34 to 42) with diabetes in India as compared with the global average of 19 (95% uncertainty interval: 17 to 21).[4] This evidence shows an alarming rise in diabesity, the coexistence of diabetes, and obesity in an individual.[9] Obesity and diabetes are interconnected as excessive weight gain leads to fat accumulation that in turn increases insulin resistance, a known pathway for diabesity.[10] Diabesity has emerged as a significant public health challenge warranting greater attention. Further, it acts as a risk factor for other NCDs such as cardiovascular diseases leading to multimorbidity.[11 12] Multimorbidity encompasses two

or more coexistent chronic conditions in an individual without defining an index disease.[13] Additionally, in contrast to many high-income countries, NCDs usually present a decade earlier (around ≥45 years of age) in India, escalating the risk of early-onset multimorbidity.[14]

The Sustainable Development Goal 3 aims to reduce the premature deaths caused due to NCDs (target 3.4) by one-third by 2030, which remains a daunting target.[15] A wide gap exists between the available and required resources to combat diabesity. Still, continuing with its commitment to achieve Universal Health Coverage (UHC), recently, India rolled out the Ayushman Bharat Programme and is establishing Health and Wellness Centres (HWCs) throughout the country that intend to provide accessible, egalitarian primary care services. Furthermore, HWCs envisage to provide a basket of comprehensive preventive and curative services that can further strengthen existing programmes such as the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular diseases, and Stroke (NPCDCS). However, these programmes and policies need evidence-based guidance for setting priorities and resource allocation. Although the burden of diabesity has steeped, India still lacks comprehensive data which poses a challenge in the formulation and implementation of actions to reduce NCD inequalities. Hence, this study was conceived to address the research gap with an aim to estimate the prevalence and identify social determinants of diabesity among adults aged ≥45 years and further compare it with the individuals having only obesity and diabetes. Additionally, it aimed to explore and compare the association between obesity, diabetes and diabesity with other selected NCDs (multimorbidity); and assess its outcomes such as life satisfaction and healthcare utilisation among older adults using nationally representative data.

## METHODS

### Study design and participants

We undertook an observational analyses employing data from the first wave of the Longitudinal Ageing Study in India (LASI) conducted in 2017–2018. LASI is a longitudinal study of 72 250 older adults (aged 45 years and above along with their spouses irrespective of age) at baseline, recruited in 2017. LASI is a multiparty undertaking by the International Institute for Population Sciences, Harvard T H Chan School of Public Health and the University of Southern California, launched by the Government of India.[16]

LASI uses a multistaged stratified area probability cluster sampling design to assemble nationally representative data for all states and union territories (UTs) of the country (except Sikkim).[16] LASI adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas to reach the eventual sampling unit. Subdistricts formed the primary sampling unit in each state/UT, which were selected randomly from the sampling frame based on the 2011 census. In the second stage, villages from selected subdistricts were chosen randomly, while in urban areas, urban wards followed by census enumeration block (CEB) were selected. After that, households from selected village/CEB were chosen to reach the target individuals making LASI a nationally representative data. Individual response rate to LASI wave 1 was 87.3%. For the present analysis, we merged information from individual (n=72 250) and biomarker (n=65 900) datasets. Further, we excluded all observations pertaining to individuals below the age of 45 years (n=6136), after which information on 59 764 individuals was obtained. As missing data accounted for 1.5% of the data, we employed a complete case analysis for 59 073 older adults.

### Procedures

LASI included the question: 'Has any health professional ever diagnosed you with the following chronic conditions or diseases?' Based on this question, we employed self-reported diagnoses of diabetes in the present study. LASI collected information on anthropometric measures—height (in centimetres) and weight (in kilograms) provided in the biomarker dataset. Height and weight were measured using a stadiometer and a Seca 803 digital weighing scale, respectively. Body mass index (BMI) was calculated as weight (in kg) divided by height (in $m^2$). We used the WHO BMI classification for Asian adults, where a BMI greater than or equal to 25 $kg/m^2$ is considered obese.[17]

The WHO's Commission of Social Determinants of Health proposes a conceptual framework for action on the social determinants of health.[18] The framework defines health as a complex phenomenon where social determinants hold a pivotal position. Further, we included information on age (in years) grouped in an interval of 5 years; sex (male and female) and residence (rural/urban). Religion was based on the question: 'what is your religion' with responses grouped as Hindu, Muslim, Christian and Others (including Sikh, Buddhist/neo-Buddhist, Jain, Jewish, Parsi/Zorastrian and others). The social group was based on two separate questions asked, that is, 'What is your caste or tribe?' with options as (1) caste, specify; (2) tribe, specify; (3) no caste/tribe; and 'Do you belong to a scheduled caste, a scheduled tribe, other backward class or none of these?' Participants' responses to the second question were directly used to form 'scheduled caste', 'scheduled tribes' and 'other backward class' groups, while 'others' comprised of participants who responded 'no caste/tribe' in the first question along with those who said 'none of these' in the second question. Years of schooling were based on the question: 'How many years of schooling have you had?', which was categorised as 'no education' for 0 years, less than 5 years, 5–9 years, and 10 years or more. The wealth quintile was classified as poorest, poorer, middle, richer and richest based on the monthly per capita expenditure.

### Outcomes

The primary outcome of interest was a categorical variable 'disease group' with four categories, (1) none (no diabetes and no obesity), (2) diabetes (only diabetes and no obesity), (3) obesity (only obesity and no diabetes) and (4) diabesity (both diabetes and obesity simultaneously).

We examined the influence of categorised disease groups obesity, diabetes and diabesity with selected NCDs (morbidities). We included these conditions based on an extensive literature search. The included NCDs were self-reported based on the question: 'Has any health professional ever diagnosed you with the following chronic conditions or diseases?' We included cancer, chronic heart disease, chronic obstructive pulmonary disorder, chronic renal failure, gastrointestinal disorders, high cholesterol, hypertension, stroke and thyroid disorders. These NCDs were selected as they are the most prevalent conditions.[19] The study further explored the association of the 'disease group' with three outcomes: (1) life satisfaction, (2) the number of inpatient visits and (3) the number of outpatient visits.

Life satisfaction was computed from the question: 'Please say how much do you strongly agree, slightly agree, neither agree nor disagree, slightly disagree, somewhat disagree or strongly disagree with the following statements':

1. In most ways, my life is close to ideal.
2. The conditions in my life are excellent.
3. I am satisfied with my life.
4. So far, I have got the important things I want in life.
5. If I could live my life again, I would change almost nothing.

Multiple correspondence analysis was used to generate life satisfaction scores based on the responses to the questions above. Further, these scores were recategorised to form a life satisfaction index classified as low, medium and high.

The number of inpatient and outpatient hospital admissions was computed from the questions: 'Over the last 12 months, how many times were you admitted as a patient to a hospital/long-term care facility for at least one night?' and 'In the past 12 months, how many times did you receive healthcare or consultation from a healthcare provider (including home visits)?', respectively.

### Statistical analysis

Results were presented as frequencies and weighted percentages to describe the study population. The burden of obesity, diabetes and diabesity was assessed using prevalence (per 100 individuals) calculated as:

$$\text{Prevalence (per 100 individuals)} = \frac{\text{All new and existing cases during a given time period}}{\text{Surveyed individuals during the same time period}} \times 100$$

In addition, the burden of obesity, diabetes and diabesity was also presented as prevalence across various background characteristics. These values were supplemented with $X^2$ p values to study bivariate associations that disease group has with the sociodemographic characteristics. A multinomial regression analysis was conducted, and adjusted relative risk ratios (RRRs) were reported to identify the predictors of obesity, diabetes and diabesity. The multivariable model was adjusted for all common morbidities. These include cancer, chronic heart disease, chronic obstructive pulmonary disorder, chronic renal failure, gastrointestinal disorders, high cholesterol, hypertension, stroke and thyroid disorders.

Further, to examine the degree of association between selected morbidities and disease groups (obesity, diabetes and diabesity) that formed multimorbidity, defined as the count of two or more chronic conditions, a multivariable binary logistic regression model was executed. The model was adjusted for the background characteristics of the individual. A stacked forest plot was made from the computed adjusted ORs. Finally, a $X^2$ test was used to investigate bivariate associations between the disease groups and selected health outcomes, including life satisfaction and number of inpatient and outpatient visits.

Statistical analysis was performed with STATA V.17.0 (STATA Corp, Texas, USA). Data visualisation was executed using RStudio (R Studio). A p value of <0.05 was considered statistically significant for all the calculations. All the estimates are reported after the appropriate application of sampling weights provided by LASI, 2017–2018.[16] The study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline (online supplemental file 1).

### Patient and public involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

## RESULTS

### Description of the study population

This study employed 59 073 participants aged ≥45 years, among whom 54% were female (table 1). Around 70% of the respondents belonged to rural areas, and almost half (50.69%) had no formal education. The majority of the participants followed Hinduism. About 21% of the respondents were from the most deprived wealth quintile.

### Prevalence and distribution of obesity, diabetes and diabesity

The overall prevalence of obesity was 21.21%, diabetes was 6.05% and diabesity was 5.87% among our study participants (table 1). Obesity was commonly observed (28.66%) among participants aged 50–54 years which reduced to 10.41% among respondents aged 70–79 years. Further, obesity was found to be akin among women (25.02%) and urban residents (33.20%). The findings suggest that 33.35% of the participants with 10 or more years of schooling were obese. Additionally, the most affluent group had the highest (29.38%) of people with obesity. Diabetes was observed among 9.38% of participants aged 75–79 years and was more common among men (7.26%). Similar to obesity, diabetes was also more

**Table 1** Descriptive statistics and patterns of obesity, diabetes and diabesity by background characteristics among older adults (aged 45 years or older), Longitudinal Ageing Study in India, wave 1, 2017–2018

| Correlates | Weighted percentages (N=59 073) % | Prevalence (per 100 individuals) | | |
|---|---|---|---|---|
| | | Obesity % (95% CI) | Diabetes % (95% CI) | Diabesity (diabetes+obesity) % (95% CI) |
| Age (in years) | | | | |
| 45–49 | 18.90 | 28.13 (28.11 to 28.14) | 2.61 (2.60 to 2.62) | 4.05 (4.04 to 4.06) |
| 50–54 | 16.06 | 28.66 (28.64 to 28.68) | 4.92 (4.91 4.93) | 4.77 (4.76 to 4.77) |
| 55–59 | 15.10 | 23.11 (23.09 to 23.12) | 5.89 (5.88 to 5.89) | 7.18. (7.17 to 7.19) |
| 60–64 | 15.32 | 19.66 (19.65 to 19.67) | 6.60 (6.59 to 6.61) | 6.92 (6.91 to 6.93) |
| 65–69 | 14.69 | 16.76 (16.74 16.77) | 7.87 (7.86 to 7.88) | 7.62 (7.17 to 7.19) |
| 70–74 | 9.38 | 12.20 (12.19 to 12.22) | 8.53 (8.52 to 8.55) | 8.11 (8.10 to 8.13) |
| 75–79 | 5.45 | 10.41 (10.39 to 10.43) | 9.38 (9.36 to 9.40) | 3.99 (3.98 to 4.01) |
| 80 and above | 5.10 | 12.07 (12.05 to 12.09) | 7.83 (7.82 to 7.85) | 1.88 (1.87 to 1.89) |
| | | $\chi 2$ p<0.001 | | |
| Sex | | | | |
| Men | 45.80 | 16.70 (16.69 to 16.71) | 7.26 (7.25 to 7.27) | 4.67 (4.66 to 4.67) |
| Women | 54.20 | 25.02 (25.01 to 25.03) | 5.03 (5.02 to 5.03) | 6.88 (6.88 to 6.89) |
| | | $\chi 2$ p<0.001 | | |
| Residence | | | | |
| Rural | 69.92 | 16.05 (16.04 to 16.06) | 5.00 (4.99 to 5.01) | 3.16 (3.16 to 3.17) |
| Urban | 30.08 | 33.20 (33.19 to 33.21) | 8.50 (8.49 to 8.51) | 12.15 (12.15 to 12.16) |
| | | $\chi 2$ p<0.001 | | |
| Religion | | | | |
| Hindu | 82.52 | 20.61 (20.60 to 20.61) | 5.82 (5.82 to 5.83) | 5.77 (5.77 to 5.78) |
| Muslim | 11.04 | 23.68 (23.66 to 23.70) | 7.01 (7.00 to7.02) | 6.26 (6.25 to 6.27) |
| Christian | 2.94 | 17.89 (17.86 to 17.92) | 8.60 (8.58 to 8.62) | 6.28 (6.27 to 6.31) |
| Others | 3.50 | 30.55 (30.52 to 30.59) | 6.32 (6.31 to 6.34) | 6.56 (6.54 to 6.57) |
| | | $\chi 2$ p<0.001 | | |
| Social group | | | | |
| Scheduled castes | 19.45 | 16.77 (16.76 to 16.78) | 5.23 (5.22 to 5.24) | 3.20 (3.20 to 3.21) |
| Scheduled tribes | 8.62 | 10.32 (10.31 to 10.34) | 2.91 (2.90 to 2.92) | 1.78 (1.78 to 1.79) |
| Other backward class | 45.54 | 22.02 (22.02 to 22.04) | 6.46 (6.46 to 6.47) | 6.99 (6.96 to 6.98) |
| Other | 26.39 | 26.63 (22.62 to 22.64) | 6.97 (6.96 to 6.98) | 6.97 (6.96 to 6.98) |
| | | $\chi 2$ p<0.001 | | |
| Years of schooling | | | | |
| No education | 50.69 | 16.06 (16.05 to 16.06) | 4.66 (4.66 to 4.67) | 3.19 (3.19 to 3.20) |
| Less than 5 | 17.71 | 20.07 (20.06 to 20.88) | 6.95 (6.94 to 6.96) | 6.11 (6.10 to 6.11) |
| 5–9 | 14.14 | 26.11 (26.10 to 26.13) | 6.45 (6.44 to 6.46) | 8.44 (8.43 to 8.45) |
| 10 or more | 17.47 | 33.35 (33.34 to 33.37) | 8.85 (8.84 to 8.86) | 11.32 (11.31 to 11.33) |
| | | $\chi 2$ p<0.001 | | |
| Wealth quintile | | | | |
| Poorest | 21.08 | 15.58 (15.57 to 15.60) | 5.36 (5.35 to 5.37) | 3.13 (3.13 to 3.14) |
| Poorer | 21.27 | 18.68 (18.67 to 18.69) | 5.46 (5.45 to 5.47) | 3.73 (3.72 to 3.74) |
| Middle | 20.39 | 21.02 (21.01 to 21.04) | 5.68 (5.68 to 5.69) | 4.92 (4.91 to 4.93) |
| Richer | 19.66 | 22.80 (22.84 to 22.86) | 6.53 (6.52 to 6.54) | 7.93 (7.92 to 7.94) |

Continued

Table 1 Continued

| Correlates | Weighted percentages (N=59 073) % | Prevalence (per 100 individuals) | | |
|---|---|---|---|---|
| | | Obesity % (95% CI) | Diabetes % (95% CI) | Diabesity (diabetes+obesity) % (95% CI) |
| Richest | 17.61 | 29.38 (29.36 to 29.39) | 7.48 (7.47 to 7.48) | 10.52 (10.51 to 10.53) |
| | | χ2 p<0.001 | | |
| Total | 100.00 | 21.21 (21.20 to 21.22) | 6.05 (6.05 to 6.06) | 5.87 (5.86 to 5.88) |

prevalent (8.50%) among the urban population and among the most educated class (8.85%). Diabetes was frequently (7.48%) observed among the most affluent individuals.

Diabesity, the co-occurrence of diabetes and obesity, was commonly observed among participants aged 55–79 years, with the prevalence ranging from 6.92% to 8.11%. The findings suggest diabesity to be common among women (6.88%) than men. We observed that 12.15% of the urban residents had diabesity, which was also more prevalent (11.32%) among the most educated group. The diabesity burden was observed to be highest (10.52%) among the most affluent class.

### Social determinants of obesity, diabetes and diabesity

The findings from multinomial analysis suggested age, sex, residence, education, and wealth index were significantly associated with obesity and diabetes (table 2). Participants in the age group of 55–59 years and 60–64 years had a higher likelihood (RRR=1.68; 95% CI: 1.20 to 2.35; p<0.001 and RRR=1.61; 95% CI: 1.18 to 2.19; p<0.001, respectively) of having diabesity. We observed women had a higher chance (RRR=2.16; 95% CI: 1.72 to 2.71; p<0.001) of having diabesity as compared with their male counterparts. Individuals from the urban areas were more likely (RRR=3.73; 95% CI: 3.07 to 4.54; p<0.001) to report diabesity than participants in rural areas. The likelihood of having diabesity increased with an increase in years of schooling (from RRR=1.97; 95% CI: 1.56 to 2.48; p<0.001 among participants who attained less than 5 years of schooling to RRR=3.26; 95% CI: 2.30 to 4.61; p<0.001 among individuals with 10 or more years of education). Among the wealth quintiles, the highest risk of having diabesity was observed among the most affluent quintile (RRR=3.60; 95% CI: 2.46 to 4.58; p<0.001) as compared with the most deprived group. Additionally, the chances of having diabesity increased with the rise in wealth.

### Association of obesity, diabetes and diabesity with selected NCDs

Obesity, diabetes and diabesity were found to be associated with the selected NCDs, which formed multimorbidity. Hypertension, hypercholesterolaemia and thyroid disease were strongly associated with obesity, diabetes and diabesity, while chronic heart disease was found to be associated with diabetes and diabesity (figure 1). This association showed multimorbidity to be akin among this group.

### Life satisfaction and healthcare utilisation among study participants

Figure 2 illustrates the life satisfaction among participants having obesity, diabetes and diabesity. Life satisfaction was observed to be minimal among the diabesity group, with almost 44 per 100 individuals rating a low life satisfaction as compared with the participants having obesity and diabetes. Overall, participants with only diabetes were most satisfied in life as compared with the obesity and diabesity groups.

Table 3 depicts respondents with diabesity require significantly higher healthcare services than those with obesity and diabetes. While only 50.62% of the obese individuals used outpatient services, a high proportion (64.63% and 66.78%) of participants with diabetes and diabesity required it, respectively. The findings suggest that 9.27% of the individuals with diabesity used inpatient services compared with 4.98% and 8.83% of the participants with obesity and diabetes, respectively.

## DISCUSSION

This study reports comprehensive findings on diabesity and its social determinants in India. We found a high prevalence of obesity as compared with diabetes, which emerged as a major contributor to diabesity. The findings suggest age, sex, residence, education and wealth index were significantly associated with obesity and diabetes. Participants aged 55–64 years, women, urban residents, most educated and the most affluent social group were at a higher risk of having diabesity. Further, we observed multimorbidity to be commonly associated with all three groups. Individuals with diabesity were found to be least satisfied as compared with the obesity and diabetes group. Additionally, participants having diabesity had the highest healthcare utilisation as compared with the other two groups (diabetes and obesity).

The prevalence of obesity in our study complements the findings of ICMR-INDIAB Study conducted in 2015, which estimated the prevalence of obesity ranged from 11.8% to 31.3% in the country.[20] Rapid urbanisation has led to an increased sedentary lifestyle and changes in dietary patterns, a probable cause for the increase

Table 2 Adjusted relative risk ratio (95% CI) estimates for obesity, diabetes and diabesity among older adults (aged 45 years or older), Longitudinal Ageing Study in India, wave 1, 2017–2018

| Correlates | Obesity | Diabetes | Diabesity |
|---|---|---|---|
| Age (in years) | | | |
| 45–49 (ref) | 1.00 | 1.00 | 1.00 |
| 50–54 | 1.08 (0.92 to 1.27) | 1.90*** (1.46 to 2.47) | 1.24 (0.92 to 1.66) |
| 55–59 | 0.85 (0.73 to 1.03) | 2.12*** (1.67 to 2.71) | 1.68*** (1.20 to 2.35) |
| 60–64 | 0.72*** (0.62 to 0.82) | 2.25*** (1.82 to 2.79) | 1.61*** (1.18 to2.19) |
| 65–69 | 0.57*** (0.48 to 0.65) | 2.37*** (1.91 to 2.93) | 1.43 (0.96 to 2.14) |
| 70–74 | 0.39*** (0.33 to 0.46) | 2.37*** (1.88 to 2.98) | 1.47 (0.82 to 2.62) |
| 75–79 | 0.30*** (00.23 to 0.39) | 2.32*** (1.67 to 3.24) | 0.67 (0.44 to 1.00) |
| 80 and above | 0.33*** (0.23 to 0.48) | 1.82*** (1.31 to 2.53) | 0.27*** (0.16 to 0.45) |
| Sex | | | |
| Men (ref) | 1.00 | 1.00 | 1.00 |
| Women | 2.14*** (1.91 to 2.40) | 1.94*** (1.68 to 2.23) | 2.16*** (1.72 to 2.71) |
| Residence | | | |
| Rural (ref) | 1.00 | 1.00 | 1.00 |
| Urban | 2.38*** (2.14 to 2.66) | 1.94*** (1.68 to 2.23) | 3.73*** (3.07 to 4.54) |
| Religion | | | |
| Hindu (ref) | 1.00 | 1.00 | 1.00 |
| Muslim | 0.99 (0.87 to 1.14) | 1.07 (0.90 to 1.27) | 0.91 (0.70 to 1.17) |
| Christian | 0.73 (0.32 to 1.62) | 1.62* (1.04 to 2.53) | 0.95 (0.47 to 1.89) |
| Others | 1.63*** (1.40 to 1.90) | 1.10 (0.84 to 1.44) | 1.25 (0.97 to 1.61) |
| Ethnicity | | | |
| Scheduled castes (ref) | 1.00 | 1.00 | 1.00 |
| Scheduled tribes | 0.66*** (0.54 to 0.82) | 1.56*** (0.43 to 0.73) | 0.64* (0.43 to 0.94) |
| Other backward class | 1.34*** (1.18 to 1.51) | 1.19* (1.04 to 2.53) | 1.76*** (1.35 to 2.30) |
| Other | 1.30*** (1.15 to 1.47) | 1.10 (0.84 to 1.45) | 1.21 (0.91 to 1.61) |
| Years of schooling | | | |
| No education (ref) | 1.00 | 1.00 | 1.00 |
| Less than 5 | 1.40*** (1.25 to 1.57) | 1.45*** (1.23 to 1.71) | 1.97*** (1.56 to 2.48) |
| 5–9 | 1.77*** (1.55 to 2.02) | 1.42*** (1.17 to 1.72) | 2.58*** (1.83 to 3.65) |
| 10 or more | 2.31*** (1.94 to 2.76) | 1.98*** (1.62 to 2.41) | 3.26*** (2.30 to 4.61) |
| Wealth quintile | | | |
| Poorest (ref) | 1.00 | 1.00 | 1.00 |
| Poorer | 1.18* (1.03 to 1.36) | 0.99 (0.79 to 1.23) | 1.15 (0.90 to 1.45) |
| Middle | 1.31*** (1.13 to 1.52) | 1.01 (0.82 to 1.26) | 1.48*** (1.15 to 1.91) |
| Richer | 1.42*** (1.22 to 1.67) | 1.17 (0.93 to 1.46) | 2.19*** (1.58 to 3.03) |
| Richest | 2.07*** (1.75 to 2.45) | 1.48*** (1.16 to 1.90) | 3.60*** (2.46 to 4.58) |

The results are adjusted for waist hip ratio (WHR) and other NCDs.
*P<0.05, **p<0.01, ***p<0.001.
NCDs, non-communicable diseases.

in obesity.[21] Further, in contrast to the 6% prevalence reported for diabetes in this study, a recent meta-analysis estimated the pooled prevalence of diabetes to be relatively higher, that is, 15%–19%, in rural and urban areas of India, respectively.[22] We used self-reported diabetes, which can be a reason for encountering low prevalence in this study. Here, it is worth noting that this also reflects a gap between the known and hidden status of diabetes in the community, which further warrants diagnosis.

We observed a 6% diabesity prevalence, similar to our previous study's findings, which estimated almost 10% prevalence of diabesity among participants aged 18 years

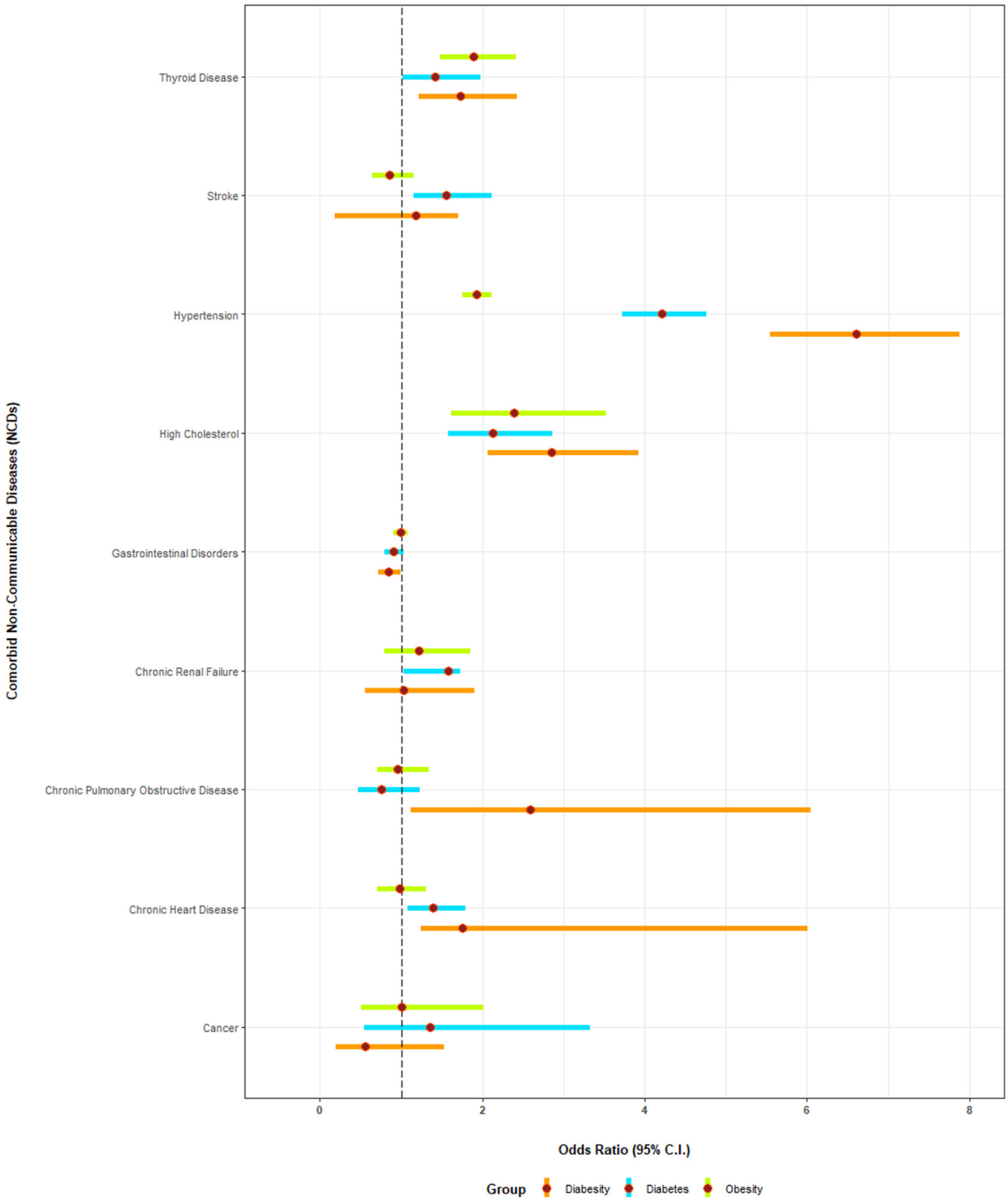


**Figure 1** Association of obesity, diabetes and diabesity with selected non-communicable diseases among older adults (aged 45 years or older), Longitudinal Ageing Study in India, wave 1, 2017–2018.

and above.[23] Although diabesity has been long recognised, there is still a paucity of literature that made the comparisons challenging. The various social determinants identified by our study align with the findings of other studies reporting correlates of obesity and diabetes.[24 25]

The micro-simulation model jointly developed by the Organization for Economic Co-operation and Development and WHO states that the distal risk factors such as low-fibre, high-fat diet and insufficient physical activity, which seem to be several steps away in the causal pathway, may lead to obesity (intermediary risk factor) which in turn can cause diabetes (proximate exposure) connected directly with disease events leading to conditions such as ischaemic heart disease.[26] This shows a link between obesity and diabetes with other NCDs leading to multimorbidity. Our study, in alignment with this, found an association between hypertension, hypercholesterolaemia, thyroid and chronic heart disease with diabesity. Furthermore, not only individual conditions but also multimorbidity can be regarded as a probable

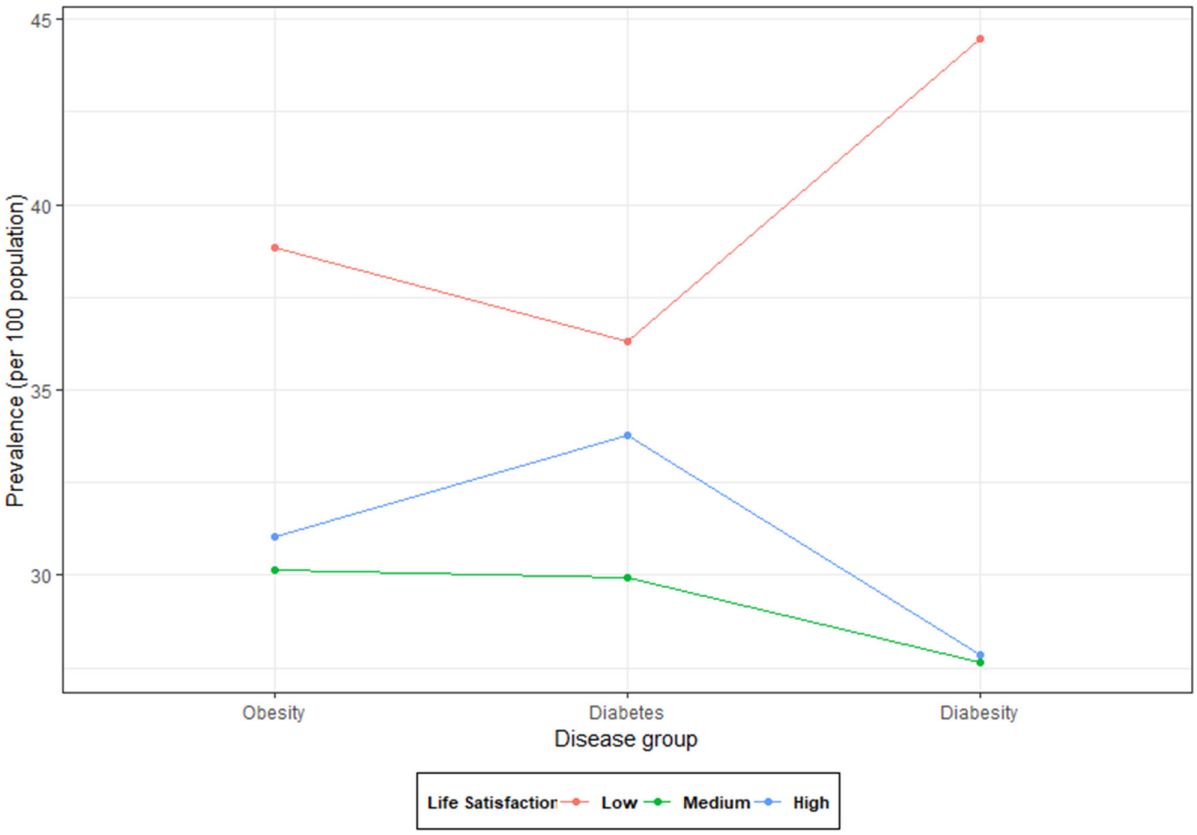


**Figure 2** Distribution of life satisfaction by obesity, diabetes and diabesity (p<0.001) among older adults (aged 45 years or older), Longitudinal Ageing Study in India, wave 1, 2017–2018.

cause for most participants to perceive low satisfaction in life.

Prevention of risk factors and early detection of NCDs can avert advanced disease progression and complications, but limited access to primary care is a significant reason for delayed NCD care and treatment.[27] Additionally, adherence and compliance to routine investigations, polypharmacy and lifestyle influence its occurrence.[28] This becomes complex with the existing socioeconomic inequalities, as stated by the blue marble health effect, where the poorest people in the wealthiest economies face health disparities.[29] Furthermore, this can significantly impact the nation's ability to attain UHC. Hence, social determinants of diabesity must be addressed to reduce disparities in NCD care. The recent initiatives such as HWCs under the Ayushman Bharat scheme provide a window of opportunity for egalitarian and accessible preventive and curative services.

## Implications for policy and practice

Managing glycaemic index among patients with diabesity is one of the priorities. Here, it is worth noting that many anti-diabetic agents, including insulin, pose a risk for weight gain. Clinicians should consider this while prescribing anti-diabetics for patients with diabesity. Nonetheless, liraglutide, a glucagon-like peptide-1 receptor

**Table 3** Association of selected healthcare utilisation with selected disease groups among older adults, Longitudinal Ageing Study in India, wave 1, 2017–2018

| Indicators of healthcare utilisation | Obesity (%) | Diabetes (%) | Diabesity (%) |
|---|---|---|---|
| Number of inpatient hospital admissions | | | |
| None | 95.02 | 91.17 | 90.73 |
| At least one | 4.98 | 8.83 | 9.27 |
| | χ2 p<0.001 | | |
| Number of outpatient visits | | | |
| Never | 49.38 | 35.37 | 33.22 |
| At least one | 50.62 | 64.63 | 66.78 |
| | χ2 p<0.001 | | |

agonist (GLP1-RA) used for treating type 2 diabetes mellitus, can also be used for weight control when given at a higher dose.[30] New anti-diabetic drugs such as GLP1-RA, sodium-glucose co-transporter 2 (SGLT2) inhibitors and tirzepatide are also effective for patients with diabesity.[31] Moreover, several studies have not only shown an effect of SGLT2 inhibitors and GLP1-RA in reducing weight but also in reducing risk of cardiovascular events in patients with type 2 diabetes with high cardiovascular risk and progression of kidney disease.[32] Hence, utilisation of these drugs in patients with diabetes, obesity and other NCDs (such as chronic kidney disease, heart failure, ischaemic heart disease) can have an impact on the history of the disease.

Additionally, the first and foremost line of management should be lifestyle interventions, including changes in diet, adequate sleep, physical exercise and controlling deleterious habits such as tobacco use.[33 34] The existing literature shows that even a modest reduction in body weight can improve blood glucose; hence, patient-centred interventions based on age, sex and multimorbidity status should be designed.[35] To achieve desired goals, appropriate modifications in the line of treatment should be made after periodical reviews. Sociocultural as well as economic backgrounds of people must also be considered to increase the acceptability and adherence to these changes.

Additionally, there is an urgent need to design guidelines on diabesity management and training the healthcare workforce in the domain. Existing programmes such as NPCDCS should be aligned to focus on diabesity apart from diabetes as a single condition. HWCs should also be used as an opportunity to provide services pertaining to diabesity management.

### Strengths and limitations

These findings are based on nationally representative data from LASI wave 1, which is a strength of this study. The study compared the prevalence and correlates of obesity, diabetes and diabesity and their association with other selected NCDs. However, it is limited by self-reported conditions and being a cross-sectional survey, it does not establish causality. Further studies are warranted to investigate the trends in diabesity using panel data.

## CONCLUSION

The findings suggest an increase in obesity prevalence has led to diabesity rise in India. Additionally, the association of diabesity with other NCDs has increased multimorbidity, which cannot be overlooked. Preventive services, including lifestyle changes at an early age, are warranted. HWCs should be explored as an opportunity to address NCD care. Rather than focusing on individual conditions, an in toto approach to multimorbidity is required. Further studies are warranted to investigate the trends in diabesity using panel data.

**Acknowledgements** The authors are grateful to the Longitudinal Ageing Study in India (LASI) for assembling and publishing accurate, nationally representative data on a range of health, biomarkers and healthcare utilisation indicators for the population aged 45 years and older. The authors are also grateful to LASI's project partners, the International Institute for Population Sciences (IIPS), Harvard T H Chan School of Public Health and the University of Southern California (USC).

**Contributors** Concept and design—SP. Acquisition, analysis or interpretation of data—PP and AS. Drafting of the manuscript—AS and PP. Critical revision of the manuscript for important intellectual content—SP, PP and AS. Statistical analysis—PP. Administrative and technical support—SP, AS and PP. Supervision—SP. Guarantor responsible for the overall content (full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish)—SP

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not required.

**Ethics approval** This study is based on secondary data obtained from LASI. The original LASI study took ethical clearance from the Indian Council of Medical Research (ICMR), New Delhi and the International Institute for Population Sciences (IIPS), Mumbai. LASI had obtained written informed consent from all the study participants.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request. The data have been archived in the public repository of the Longitudinal Ageing Study in India, 2017-2018. Access to the dataset requires registration and is granted only for legitimate research purposes. A guide for how to apply for dataset access is available at https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf. The data can be accessed using the link: https://www.iipsindia.ac.in/content/lasi-wave-i.



**ORCID iDs**
Abhinav Sinha http://orcid.org/0000-0001-7702-3671
Parul Puri http://orcid.org/0000-0001-6272-837X

## REFERENCES

1 World Health Organization. *Global action plan for the prevention and control of non-communicable diseases 2013-2020*. World Health Organization, 2013.
2 Saeedi P, Petersohn I, Salpea P, *et al*. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract* 2019;157:107843.
3 Roglic G. Who global report on diabetes: a summary. *Int J Noncommun Dis* 2016;1:3.
4 India State-Level Disease Burden Initiative Diabetes Collaborators. The increasing burden of diabetes and variations among the states of India: the global burden of disease study 1990-2016. *Lancet Glob Health* 2018;6:e1352–62.
5 Ezzati M, Hoorn SV, Rodgers A, *et al*. Estimates of global and regional potential health gains from reducing multiple major risk factors. *Lancet* 2003;362:271–80.

6 Sommer I, Griebler U, Mahlknecht P, *et al*. Socioeconomic inequalities in non-communicable diseases and their risk factors: an overview of systematic reviews. *BMC Public Health* 2015;15:914.
7 Burki T. European Commission classifies obesity as a chronic disease. *Lancet Diabetes Endocrinol* 2021;9:418.
8 Yoon K-H, Lee J-H, Kim J-W, *et al*. Epidemic obesity and type 2 diabetes in Asia. *Lancet* 2006;368:1681–8.
9 Ng ACT, Delgado V, Borlaug BA, *et al*. Diabesity: the combined burden of obesity and diabetes on heart disease and the role of imaging. *Nat Rev Cardiol* 2021;18:291–304.
10 Araneta MRG, Wingard DL, Barrett-Connor E. Type 2 diabetes and metabolic syndrome in Filipina-American women : a high-risk nonobese population. *Diabetes Care* 2002;25:494–9.
11 O'Donnell MJ, Xavier D, Liu L, *et al*. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. *Lancet* 2010;376:112–23.
12 Rosengren A, Hawken S, Ôunpuu S, *et al*. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364:953–62.
13 MacMahon S, Calverley P, Chaturvedi N, *et al*. *Multimorbidity: a priority for global health research. The*. 127. London, UK: Academy of Medical Sciences, 2018.
14 Siegel KR, Patel SA, Ali MK. Non-Communicable diseases in South Asia: contemporary perspectives. *Br Med Bull* 2014;111:31–44.
15 Sustainable Development Knowledge Platform. Transforming our world: the 2030 agenda for sustainable development, 2015. Available: https://sustainabledevelopment.un.org/post2015/transformingourworld/publication [Accessed 06 Jan 2022].
16 International Institute for Population Sciences (IIPS). Longitudinal Ageing Study in India (LASI) [Internet], 2020. Available: https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf
17 Dhawan D, Sharma S. Abdominal obesity, adipokines and non-communicable diseases. *J Steroid Biochem Mol Biol* []. 2020;203:105737.
18 WHO. *A Conceptual Framework for Action on the Social Determinants of Health. Social Determinants of Health Discussion Paper 2 (Policy and Practice): Debates, Policy & Practice, Case Studies*. Geneva, Switzerland, 2010.
19 Cecchini M, Sassi F, Lauer JA, *et al*. Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost-effectiveness. *Lancet* 2010;376:1775–84.
20 Pradeepa R, Anjana RM, Joshi SR, *et al*. Prevalence of generalized & abdominal obesity in urban & rural India--the ICMR-INDIAB Study (Phase-I) [ICMR- NDIAB-3]. *Indian J Med Res* 2015;142:139.
21 Chatterjee P. India sees parallel rise in malnutrition and obesity. *Lancet* 2002;360:1948.
22 Ranasinghe P, Jayawardena R, Gamage N, *et al*. Prevalence and trends of the diabetes epidemic in urban and rural India: a pooled systematic review and meta-analysis of 1.7 million adults. *Ann Epidemiol* 2021;58:128–48.
23 Heymsfield SB, Avena NM, Baier L, *et al*. Characteristics and correlates of diabesity in India: a secondary data analysis of World health survey. *In12th International Congress on Obesity*, 2014:S1-S17.
24 Palo SK, Swain S, Priyadarshini S, *et al*. Epidemiology of obesity and its related morbidities among rural population attending a primary health centre of Odisha, India. *J Family Med Prim Care* 2019;8:203.
25 Ramachandran A, Ma RCW, Snehalatha C. Diabetes in Asia. *Lancet* 2010;375:408–18.
26 Sustainable Development Knowledge Platform. Transforming our world: the 2030 agenda for sustainable development. Available: https://sustainabledevelopment.un.org/post2015/transformingourworld/publication [Accessed 06 Jan 2022].
27 Di Cesare M, Khang Y-H, Asaria P, *et al*. Inequalities in non-communicable diseases and effective responses. *Lancet* 2013;381:585–97.
28 Jayanna K, Swaroop N, Kar A, *et al*. Designing a comprehensive non-communicable diseases (Ncd) programme for hypertension and diabetes at primary health care level: evidence and experience from urban Karnataka, South India. *BMC Public Health* 2019;19:1–2.
29 Hotez PJ. *Blue marble health: an innovative plan to fight diseases of the poor amid wealth*. JHU Press, 2016.
30 Lin C-H, Shao L, Zhang Y-M, *et al*. An evaluation of liraglutide including its efficacy and safety for the treatment of obesity. *Expert Opin Pharmacother* 2020;21:275–85.
31 Kaul S. Mitigating cardiovascular risk in type 2 diabetes with antidiabetes drugs: a review of principal cardiovascular outcome results of EMPA-REG outcome, leader, and SUSTAIN-6 trials. *Diabetes Care* 2017;40:821–31.
32 Lazzaroni E, Ben Nasr M, Loretelli C, *et al*. Anti-Diabetic drugs and weight loss in patients with type 2 diabetes. *Pharmacol Res* 2021;171:105782.
33 Merlotti C, Morabito A, Pontiroli AE. Prevention of type 2 diabetes; a systematic review and meta-analysis of different intervention strategies. *Diabetes, Obesity and Metabolism* 2014;16:719–27.
34 Baillot A, Romain AJ, Boisvert-Vigneault K, *et al*. Effects of lifestyle interventions that include a physical activity component in class II and III obese individuals: a systematic review and meta-analysis. *PLoS One* 2015;10:e0119017.
35 Franz MJ, Boucher JL, Rutten-Ramos S, *et al*. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: a systematic review and meta-analysis of randomized clinical trials. *J Acad Nutr Diet* 2015;115:1447–63.

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation | Page No |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 4 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5 |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants | 5 |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | *6* |
| Bias | 9 | Describe any efforts to address potential sources of bias | 6 |
| Study size | 10 | Explain how the study size was arrived at | 5 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 6 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | 7 |
| | | (*c*) Explain how missing data were addressed | 7 |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy | |
| | | (*e*) Describe any sensitivity analyses | |

Continued on next page

| | | | |
|---|---|---|---|
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 8 |
| | | (b) Give reasons for non-participation at each stage | NA |
| | | (c) Consider use of a flow diagram | NA |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 8 |
| | | (b) Indicate number of participants with missing data for each variable of interest | 8 |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) | NA |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time | |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure | |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures | 8 |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | 8 |
| | | (*b*) Report category boundaries when continuous variables were categorized | 8 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 14-17 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 18 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 20 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 20 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 20 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 21 |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.



Sinha A, *et al. BMJ Open* 2022; 12:e061154. doi: 10.1136/bmjopen-2022-061154