# Body-mass index and obesity in urban and rural China: findings from consecutive nationally representative surveys during 2004–18

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## Summary

**Background** In China, mean body-mass index (BMI) and obesity in adults have increased steadily since the early 1980s. However, to our knowledge, there has been no reliable assessment of recent trends, nationally, regionally, or in certain population subgroups. To address this evidence gap, we present detailed analyses of relevant data from six consecutive nationally representative health surveys done between 2004 and 2018. We aimed to examine the long-term and recent trends in mean BMI and prevalence of obesity among Chinese adults, with specific emphasis on changes before and after 2010 (when various national non-communicable disease prevention programmes were initiated), assess how these trends might vary by sex, age, urban–rural locality, and socioeconomic status, and estimate the number of people who were obese in 2018 compared with 2004.

**Methods** We used data from the China Chronic Disease and Risk Factors Surveillance programme, which was established in 2004 with the aim to provide periodic nationwide data on the prevalence of major chronic diseases and the associated behavioural and metabolic risk factors in the general population. Between 2004 and 2018 six nationally representative surveys were done. 776 571 individuals were invited and 746 020 (96·1%) participated, including 33 051 in 2004, 51 050 in 2007, 98 174 in 2010, 189 115 in 2013, 189 754 in 2015, and 184 876 in 2018. After exclusions, 645 223 participants aged 18–69 years remained for the present analyses. The mean BMI and prevalence of obesity (BMI ≥30 kg/m²) were calculated and time trends compared by sex, age, urban–rural locality, geographical region, and socioeconomic status.

**Findings** Standardised mean BMI levels rose from 22·7 kg/m² (95% CI 22·5–22·9) in 2004 to 24·4 kg/m² (24·3–24·6) in 2018 and obesity prevalence from 3·1% (2·5–3·7) to 8·1% (7·6–8·7). Between 2010 and 2018, mean BMI rose by 0·09 kg/m² annually (0·06–0·11), which was half of that reported during 2004–10 (0·17 kg/m², 95% CI 0·12–0·22). Similarly, the annual increase in obesity prevalence was somewhat smaller after 2010 than before 2010 (6·0% annual relative increase, 95% CI 4·4–7·6 *vs* 8·7% annual relative increase, 4·9–12·8; p=0·13). Since 2010, the rise in mean BMI and obesity prevalence has slowed down substantially in urban men and women, and moderately in rural men, but continued steadily in rural women. By 2018, mean BMI was higher in rural than urban women (24·3 kg/m² *vs* 23·9 kg/m²; p=0·0045), but remained lower in rural than urban men (24·5 kg/m² *vs* 25·1 kg/m²; p=0·0007). Across all six surveys, mean BMI was persistently lower in women with higher levels of education compared with women with lower levels of education, but the inverse was true among men. Overall, an estimated 85 million adults (95% CI 70 million–100 million; 48 million men [95% CI 39 million–57 million] and 37 million women [31 million–43 million]) aged 18–69 years in China were obese in 2018, which was three times as many as in 2004.

**Interpretation** In China, the rise in mean BMI among the adult population appears to have slowed down over the past decade. However, we found divergent trends by sex, geographical area, and socioeconomic status, highlighting the need for a more targeted approach to prevent further increases in obesity in the Chinese general population.

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## Introduction

Obesity is a major risk factor for cardiometabolic diseases, renal disease, and many cancers,[1–5] affecting 670 million adults worldwide in 2016.[6] Globally, the prevalence of obesity in adults has almost tripled since 1975. In some middle-income countries, mean body-mass index (BMI) has increased by 5 kg/m² and prevalence of obesity by more than ten times.[6] In China, mean BMI and obesity have been increasing steadily since the 1980s following rapid economic development[7,8] but remained, at least by 2010, well below the levels seen in most other middle-income and high-income countries. Since 2010 national

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## Research in context

### Evidence before this study

We searched PubMed for studies on national trends in mean body-mass index (BMI) and obesity in China, published from Jan 1, 2010, to March 1, 2021, with no language restrictions, using the search terms ((obesity[MeSH Terms] OR (body mass index[MeSH Terms])) AND adult[MeSH Terms] AND China[MeSH Terms]) AND trend*[Title/Abstract]. We identified several studies that reported a rise in mean BMI and obesity in China until 2013 in both urban and rural areas and across different education groups. Evidence on trends after 2013 in BMI and obesity in China was mainly based on studies in particular regions and from statistical models in global studies. One study reported a steady rise in mean BMI and obesity (defined as BMI ≥27·5 kg/m$^2$) among adults aged 18–80 years during 1993–2015. Another study found increasing trends in the prevalence of obesity (defined as BMI ≥28 kg/m$^2$) among rural men aged 15–49 years during 2010–14. The use of the Chinese BMI cutoff for obesity in these studies, which was proposed in the early 2000s, restricted the ability to compare with data in China collected before 2004 or with data from other countries. The most recent study in China that classified obesity using the conventional WHO definition covered only a 5-year period during 2013–18 and found increasing prevalence; however, this study did not examine long-term trends before 2013, nor the trend in mean BMI. Furthermore, the study used an unconventioal sampling method, leading to an unexpected much lower obesity prevalence than reported in other nationwide surveys in China. To our knowledge, there are no national studies covering a prolonged time period in the years after 2015 for mean BMI or the prevalence of obesity using internationally comparable definitions (BMI ≥30 kg/m$^2$) in China.

### Added value of this study

To our knowledge, the present study provides the most up-to-date analyses of long-term and more recent trends in mean BMI and obesity prevalence in China. By using six large national surveys during 2004–18, we examined BMI and obesity prevalence both nationally and by sex, age, urban–rural locality, education, occupation, and geographical region. Our study showed that, in contrast to previous predictions, the increase in mean BMI and obesity prevalence appeared to slow down in China after 2010, when a number of large nationwide prevention programmes targeting non-communicable diseases and obesity were rolled out. However, there were divergent trends in urban and rural areas, particularly among women. Since 2010, the increase in mean BMI and obesity prevalence slowed down substantially in urban men and women, and moderately in rural men, but continued steadily in rural women. By 2018, mean BMI was higher in rural than urban women, but remained lower in rural than urban men. Among women, the mean BMI was persistently lower in those with higher education than in those with lower education across all six surveys, but the inverse was true among men. In China, 85 million adults aged 18–69 years (48 million men and 37 million women) were obese in 2018, representing a more than three-times increase since 2004.

### Implications of all the available evidence

Although the total number of adults who were obese reached 85 million in 2018, the rise in mean BMI and obesity appeared to be slowing down in urban China, while in rural China BMI and obesity continued to rise, especially among women. In addition to divergent trends in urban and rural areas, there were also large disparities in BMI and obesity trends by sex, age, and socioeconomic status. Although further monitoring is needed to assess the longer-term trends and changing patterns, the present study findings highlight the pressing need for more targeted health policies to reduce further increases in obesity in the general population, with a gradual shift towards placing more emphasis on rural populations.

programmes targeting obesity and non-communicable disease prevention have been rolled out in China, including the National Demonstration Areas for Comprehensive Prevention and Control of Non-communicable Diseases and the China Healthy Lifestyle for All Initiative.[9,10] In 2013, the World Health Assembly also set an ambitious global target for control of non-communicable diseases, including to halt by 2025 the rise in the prevalence of obesity compared with 2010.[11] Careful monitoring of long-term trends in BMI and obesity in general populations is essential to evaluate the likely success of various national and international initiatives and inform the development of country-specific health policies.

Some studies have previously reported on the rising trend in BMI and obesity prevalence in China, but these mainly used national survey data collected before 2013,[12–19] including some global pooling studies,[6,20] and tended to define obesity differently from the definitions used in most international studies.[21] The paucity of reliable data on China's recent trends in mean BMI and obesity, both nationally and subnationally, for example, by urban–rural locality, which would reflect different stages of socioeconomic development, has led to substantial uncertainty over whether the rise in BMI will continue persistently. Moreover, important questions also persist concerning whether the rising trends in BMI might vary between men and women, urban and rural areas, or by socioeconomic or education status, which could inform more targeted intervention measures.

To address this evidence gap, we present detailed analyses of relevant data from six consecutive nationally representative health surveys done between 2004 and 2018. We aimed to examine the long-term and recent trends in mean BMI and prevalence of obesity among

Chinese adults from 2004 to 2018, with specific emphasis on changes before and after 2010 (when various national non-communicable disease prevention programmes were initiated), assess how these trends might vary by sex, age, urban–rural locality, and socioeconomic status, and estimate the number of people who were obese in 2018 compared with 2004.

## Methods

### Survey design and populations

We used data from the China Chronic Disease and Risk Factors Surveillance (CCDRFS) programme, which was established in 2004 with the aim to provide periodic nationwide data on the prevalence of major chronic diseases and the associated behavioural and metabolic risk factors in the general population. Details of the design, objectives, and survey methods of the CCDRFS have been described elsewhere,[22–24] and are summarised in the appendix (pp 3–5). Briefly, the CCDRFS was incorporated into the Chinese Disease Surveillance Point (DSP) system, which covers 324 million people (around 24% of the total population in China) across all 31 provinces, autonomous regions, and municipalities.[25,26] Each DSP area covers a rural county or urban district, which was selected using a multistage stratified cluster sampling scheme.

For each CCDRFS survey, participants were selected using multistage stratified cluster sampling within DSPs (figure 1; appendix pp 3–5). Across all six surveys, 776 571 individuals were invited and 746 020 (96·1%) participated, including 33 051 (response rate 99·6%) in 2004, 51 050 (99·1%) in 2007, 98 174 (90·5%) in 2010, 189 115 (97·6%) in 2013, 189 754 (97·4%) in 2015, and 184 876 (94·9%) in 2018. The study protocols for each survey were approved by the relevant national and regional ethics review committees. All participants provided written informed consent.

### Data collection

In each survey, trained health workers collected detailed questionnaire data on demographics and socioeconomic information, and took a range of physical measurements, including standing height and bodyweight. In 2004 and 2007, height was measured using wall-mounted stature meters. From 2010, height was measured using mechanical anthropometry stadiometers (Bengbu Equipment; Anhui, China). In 2004, weight was measured using metal body analogue weighing scales. Since 2007, weight was measured using the same model of electronic body scales, which were calibrated on a regular basis according to a standard protocol (appendix pp 3–8).

See Online for appendix

### Statistical analysis

74 741 (10·0%) participants younger than 18 years or older than 69 years were excluded because these age ranges were not considered in the 2004 survey. We also excluded 26 056 (3·9%) participants with incomplete demographic or height or weight data across different surveys. After

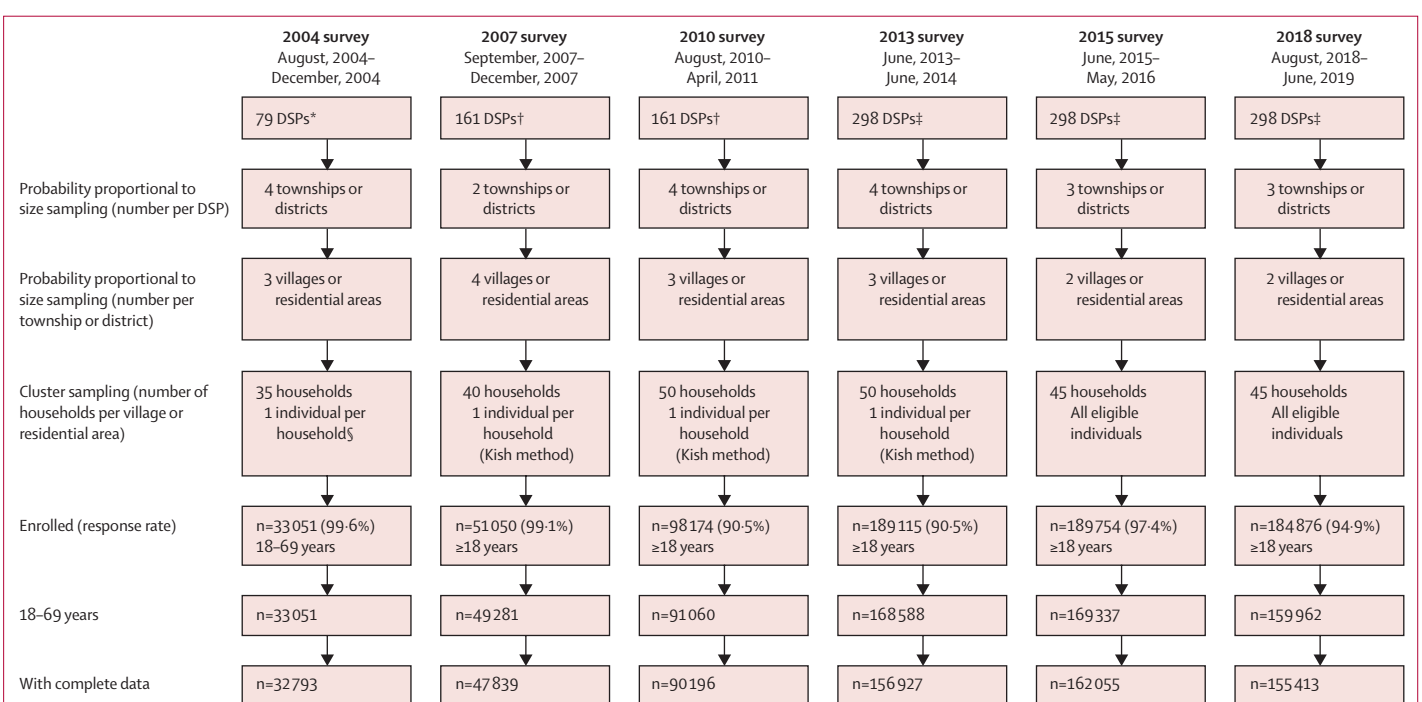


***Figure 1*: Flow diagram of study design and sampling procedure of China Chronic Disease and Risk Factors Surveillance 2004–18.**
Biochemical data were available from 2010. DSP=Disease Surveillance Point. *Half of all DSPs (161) were selected using stratified sampling. †All DSPs were selected. ‡Half of all DSPs (605) were selected using stratified sampling. §In each household, the individual whose day of birth was closest to the 21st of any month was invited.

these exclusions, 645 223 participants aged 18–69 years remained for the present analyses (figure 1).

We used standard WHO criteria to define overweight (BMI ≥25 kg/m²) and obesity (BMI ≥30 kg/m²). The mean BMI and prevalence of obesity in each survey were calculated after incorporating stratification, clustering, and sample weights. To account for natural changes in population structures, multistage sampling design, non-response, and post-stratification, standard sample weights were constructed based on the 2010 China census population (appendix pp 4–5).

For mean BMI and prevalence of obesity, calculations were also done separately by sex (men *vs* women), locality of residence (urban *vs* rural), age (five groups), education (four groups), occupation (agriculture-related, other manual work, non-manual work, not working or retired), and geographical region (central, east, north, northeast, northwest, south, or southwest). When results were not stratified by age, standardised mean and prevalence were calculated by averaging the sex-specific and age-specific mean and prevalence in each survey weighted by the 2010 China census population. We used the proc surveymeans procedure in SAS to estimate standard errors and 95% CIs, using Taylor series linearisations with finite population correction. All analyses accounted for complex sample design including clustering, stratification, and sample weights.

We compared trends in BMI and obesity before and after 2010 to assess potential effects of new national programmes related to obesity and non-communicable disease prevention introduced around 2010. Annual changes in mean BMI were calculated as the absolute difference in mean BMI between the start and end years divided by total number of years covered. The annual

| | 2004 (n=32 793) | 2007 (n=47 839) | 2010 (n=90 196) | 2013 (n=156 927) | 2015 (n=162 055) | 2018 (n=155 413) | $p_{trend}$ |
|---|---|---|---|---|---|---|---|
| Sex | .. | .. | .. | .. | .. | .. | 0·4782 |
| Women | 18 254 (55·7%) | 25 166 (52·7%) | 49 076 (54·4%) | 90 566 (57·7%) | 87 452 (54·0%) | 87 926 (56·6%) | .. |
| Men | 14 539 (44·3%) | 22 673 (47·3%) | 41 120 (45·6%) | 66 361 (42·3%) | 74 603 (46·0%) | 67 487 (43·4%) | .. |
| Age, years | | | | | | | |
| 18–29 | 3906 (11·9%) | 6280 (13·1%) | 14 542 (16·1%) | 13 981 (8·9%) | 15 803 (9·8%) | 9412 (6·1%) | 0·1253 |
| 30–39 | 8636 (26·3%) | 11 551 (24·1%) | 17 724 (19·7%) | 22 555 (14·4%) | 21 671 (13·4%) | 17 755 (11·4%) | 0·0003 |
| 40–49 | 8990 (27·4%) | 12 168 (25·4%) | 24 605 (27·3%) | 43 127 (27·5%) | 40 043 (24·7%) | 32 349 (20·8%) | 0·1248 |
| 50–59 | 7089 (21·6%) | 11 096 (23·2%) | 20 725 (22·9%) | 43 885 (27·9%) | 44 307 (27·3%) | 47 124 (30·3%) | 0·0042 |
| 60–69 | 4172 (12·7%) | 6744 (14·1%) | 12 600 (14·0%) | 33 379 (21·3%) | 40 231 (24·8%) | 48 773 (31·4%) | 0·0048 |
| Age, years | 44·1 (12·2) | 45·0 (12·7) | 44·3 (13·1) | 48·9 (12·3) | 49·4 (12·6) | 51·9 (12·0) | 0·0070 |
| Setting | .. | .. | .. | .. | .. | .. | 0·0011 |
| Urban | 12 295 (37·5%) | 18 621 (38·9%) | 35 560 (39·4%) | 65 069 (41·5%) | 69 044 (42·6%) | 70 861 (45·6%) | .. |
| Rural | 20 498 (62·5%) | 29 218 (61·1%) | 54 636 (60·6%) | 91 858 (58·5%) | 93 011 (57·4%) | 84 552 (54·4%) | .. |
| Region | | | | | | | |
| Central | 3556 (10·8%) | 6336 (13·2%) | 12 166 (13·5%) | 19 461 (12·4%) | 20 021 (12·4%) | 19 425 (12·5%) | 0·5505 |
| East | 7592 (23·1%) | 11 963 (25·0%) | 21 736 (24·1%) | 40 731 (26·0%) | 41 062 (25·3%) | 38 667 (24·9%) | 0·1645 |
| North | 4237 (12·9%) | 6809 (14·2%) | 12 795 (14·2%) | 23 007 (14·7%) | 23 210 (14·3%) | 22 476 (14·5%) | 0·0740 |
| Northeast | 4118 (12·6%) | 5112 (10·7%) | 10 060 (11·2%) | 15 262 (9·7%) | 15 522 (9·6%) | 14 917 (9·6%) | 0·0166 |
| Northwest | 4976 (15·2%) | 5928 (12·4%) | 11 060 (12·3%) | 20 446 (13·0%) | 21 419 (13·2%) | 20 796 (13·4%) | 0·5254 |
| South | 2918 (8·9%) | 4096 (8·6%) | 7685 (8·5%) | 15 390 (9·8%) | 16 055 (9·9%) | 15 762 (10·1%) | 0·0399 |
| Southwest | 5396 (16·5%) | 7595 (15·9%) | 14 694 (16·3%) | 22 630 (14·4%) | 24 766 (15·3%) | 23 370 (15·0%) | 0·0795 |
| Education | | | | | | | |
| No education | 6111 (18·6%) | 11 907 (24·9%) | 19 484 (21·6%) | 39 477 (25·2%) | 42 329 (26·1%) | 41 026 (26·4%) | 0·0517 |
| Primary | 9553 (29·1%) | 9363 (19·6%) | 17 430 (19·3%) | 31 303 (19·9%) | 32 583 (20·1%) | 30 320 (19·5%) | 0·1549 |
| Secondary | 10 706 (32·6%) | 15 479 (32·4%) | 30 111 (33·4%) | 52 183 (33·3%) | 52 604 (32·5%) | 50 398 (32·4%) | 0·9287 |
| College | 6423 (19·6%) | 11 090 (23·1%) | 23 171 (25·7%) | 33 964 (21·6%) | 34 539 (21·3%) | 33 669 (21·7%) | 0·9206 |
| Occupation | | | | | | | |
| Agriculture-related | 18 569 (56·6%) | 23 364 (48·9%) | 43 148 (47·8%) | 74 375 (47·4%) | 74 418 (45·9%) | 68 999 (44·4%) | 0·0177 |
| Other manual work | 1867 (5·7%) | 3290 (6·9%) | 3726 (4·1%) | 7534 (4·8%) | 6725 (4·1%) | 5431 (3·5%) | 0·0580 |
| Non-manual work | 6481 (19·8%) | 12 951 (27·0%) | 34 086 (37·8%) | 59 794 (38·1%) | 62 068 (38·3%) | 58 769 (37·8%) | 0·0271 |
| Not working | 3536 (10·8%) | 4491 (9·4%) | 3174 (3·5%) | 4568 (2·9%) | 6847 (4·2%) | 7554 (4·9%) | 0·0768 |
| Retired | 2340 (7·1%) | 3743 (7·8%) | 6062 (6·7%) | 10 656 (6·8%) | 11 997 (7·4%) | 14 660 (9·4%) | 0·2747 |

Data are n (%) or mean (SD), unless otherwise indicated.

***Table 1:*** **Characteristics of participants in each survey**

relative changes in overweight and obesity prevalence were calculated as the difference in prevalence between the start and end years divided by the prevalence in the start year annualised by accounting for compounding (appendix pp 7–8). We did Student's *t* test for trends for each characteristic in table 1 and Welch's *t* test for comparisons of mean between groups and over time, and to compare trends in mean BMI before and after 2010. We used a simulation-based method[27] for prevalence of obesity and overweight (appendix p 8). We did not adjust for possible multiple comparisons involved in our analysis.

All analyses were done in SAS version 9.4 or R version 3.6.0.

### Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

## Results

Between 2004 and 2018, the number of participants included in each CCDRFS survey increased from 32 793 to 155 413, with increasing proportions of older people (mean age increased from 44 years to 52 years; $p_{trend}$=0·0070) and urban residents (12 295 [38%] to 70 861 [46%]; $p_{trend}$=0·0011; table 1). A higher proportion of participants performed non-manual work in 2018 compared with 2004 (6481 [20%] to 58 769 [38%]; $p_{trend}$=0·0277), whereas the inverse was true for agriculture-related work (18 569 [57%] to 68 999 [44%]; $p_{trend}$=0·0171). There was little change in the distribution of samples across regions and education levels over the study period.

Standardised mean BMI levels rose from 22·7 kg/m² (95% CI 22·5–22·9) in 2004 to 24·4 kg/m² (24·3–24·6) in 2018, driven by an increase in bodyweight rather than changes in height (appendix p 10). From 2004 to 2010, the mean BMI rose by 0·17 kg/m² (95% CI 0·12–0·22) annually, which was around twice the annual increase (0·09 kg/m², 95% CI 0·06–0·11) observed between 2010 and 2018 (table 2). Consistent with an increase in mean BMI and prevalence of obesity, we found that BMI distributions became wider from 2004 to 2018 (appendix p 11), as did their corresponding SDs, but the increase in SD was smaller after 2010, especially among men (appendix p 12). In 2004, men had a lower mean BMI and prevalence of obesity than did women, but by 2018 this pattern had reversed, as BMI rose more rapidly in men than in women between 2004 and 2018 (annual change 0·16 kg/m², 95% CI 0·14–0·18 *vs* 0·09 kg/m², 0·07–0·11; p<0·0001; table 2).

In 2018, the standardised prevalence of obesity was 8·1% (95% CI 7·6–8·7), more than twice as high as in 2004 (3·1%, 95% CI 2·5–3·7). An estimated 85 million adults (95% CI 70 million–100 million; 48 million men [95% CI 39 million–57 million] and 37 million women [31 million–43 million]) aged 18–69 years in China were obese in 2018, which was three times as many as in 2004 (total 28 million, 95% CI 17 million–38 million; 12 million men [95% CI 7 million–17 million] and 16 million women [10 million–21 million]). The rise in obesity over the study period was somewhat smaller after 2010 (6·0% annual relative increase, 95% CI 4·4–7·6) compared with before 2010 (8·7% annual relative increase, 4·9–12·8; p=0·13; table 2). The slowdown in the rise of obesity prevalence was evident across all regions except in southern China, although it was distributed unevenly across age groups and education levels (appendix pp 22–23). Likewise, for the prevalence of overweight, the annual increase was about half as fast after 2010 compared with before 2010 (2·7%, 95% CI 2·0–3·4 *vs* 6·4%, 4·6–8·4; p=0·0007; table 2).

The trends in mean BMI were largely similar across different age groups for men and women in both urban

| | Men | | | Women | | | Both | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2004–10 | 2010–18 | p value* | 2004–10 | 2010–18 | p value* | 2004–10 | 2010–18 | p value* |
| **Change (95% CI) in mean BMI (kg/m²)** | | | | | | | | | |
| Overall | 0·22 (0·17 to 0·27) | 0·11 (0·08 to 0·14) | 0·0014 | 0·12 (0·07 to 0·17) | 0·06 (0·03 to 0·09) | 0·0299 | 0·17 (0·12 to 0·22) | 0·09 (0·06 to 0·11) | 0·0044 |
| Urban | 0·22 (0·15 to 0·28) | 0·10 (0·05 to 0·15) | 0·0067 | 0·13 (0·07 to 0·20) | 0·03 (–0·01 to 0·07) | 0·0102 | 0·17 (0·12 to 0·23) | 0·06 (0·02 to 0·10) | 0·0046 |
| Rural | 0·21 (0·15 to 0·28) | 0·11 (0·08 to 0·15) | 0·0096 | 0·12 (0·05 to 0·19) | 0·09 (0·05 to 0·12) | 0·2507 | 0·17 (0·10 to 0·23) | 0·10 (0·07 to 0·13) | 0·0568 |
| **Percentage change (95% CI) in obesity prevalence** | | | | | | | | | |
| Overall | 12·2 (7·8 to 17·1) | 7·5 (5·7 to 9·4) | 0·0464 | 5·8 (2·1 to 9·8) | 4·4 (2·7 to 6·1) | 0·2796 | 8·7 (4·9 to 12·8) | 6·0 (4·4 to 7·6) | 0·1346 |
| Urban | 13·5 (7·2 to 20·9) | 6·7 (4·2 to 9·2) | 0·0400 | 6·3 (0·8 to 12·8) | 2·7 (0·4 to 5·1) | 0·1546 | 9·7 (4·2 to 16·1) | 5·0 (2·8 to 7·2) | 0·0831 |
| Rural | 11·3 (5·5 to 18·1) | 7·5 (5·0 to 10·1) | 0·1600 | 5·6 (0·7 to 11·0) | 5·5 (3·2 to 7·9) | 0·4983 | 8·0 (3·1 to 13·5) | 6·5 (4·4 to 8·7) | 0·3257 |
| **Percentage change (95% CI) in overweight prevalence** | | | | | | | | | |
| Overall | 8·7 (6·6 to 10·9) | 3·4 (2·6 to 4·2) | <0·0001 | 4·2 (2·3 to 6·2) | 1·9 (1·1 to 2·8) | 0·0313 | 6·4 (4·6 to 8·4) | 2·7 (2·0 to 3·4) | 0·0007 |
| Urban | 7·9 (5·5 to 10·5) | 2·5 (1·4 to 3·6) | 0·0002 | 4·0 (1·6 to 6·6) | 1·0 (–0·3 to 2·3) | 0·0357 | 6·1 (3·8 to 8·5) | 1·9 (0·8 to 3·0) | 0·0019 |
| Rural | 9·4 (6·3 to 12·8) | 3·8 (2·7 to 4·8) | 0·0009 | 4·4 (1·7 to 7·3) | 2·6 (1·5 to 3·7) | 0·1498 | 6·7 (4·0 to 9·7) | 3·2 (2·2 to 4·2) | 0·0168 |

BMI=body-mass index. *p value for difference in annual changes for 2004–10 versus 2010–18.

*Table 2:* **Annual change in standardised mean BMI and prevalence of obesity and overweight during 2004–10 and 2010–18**

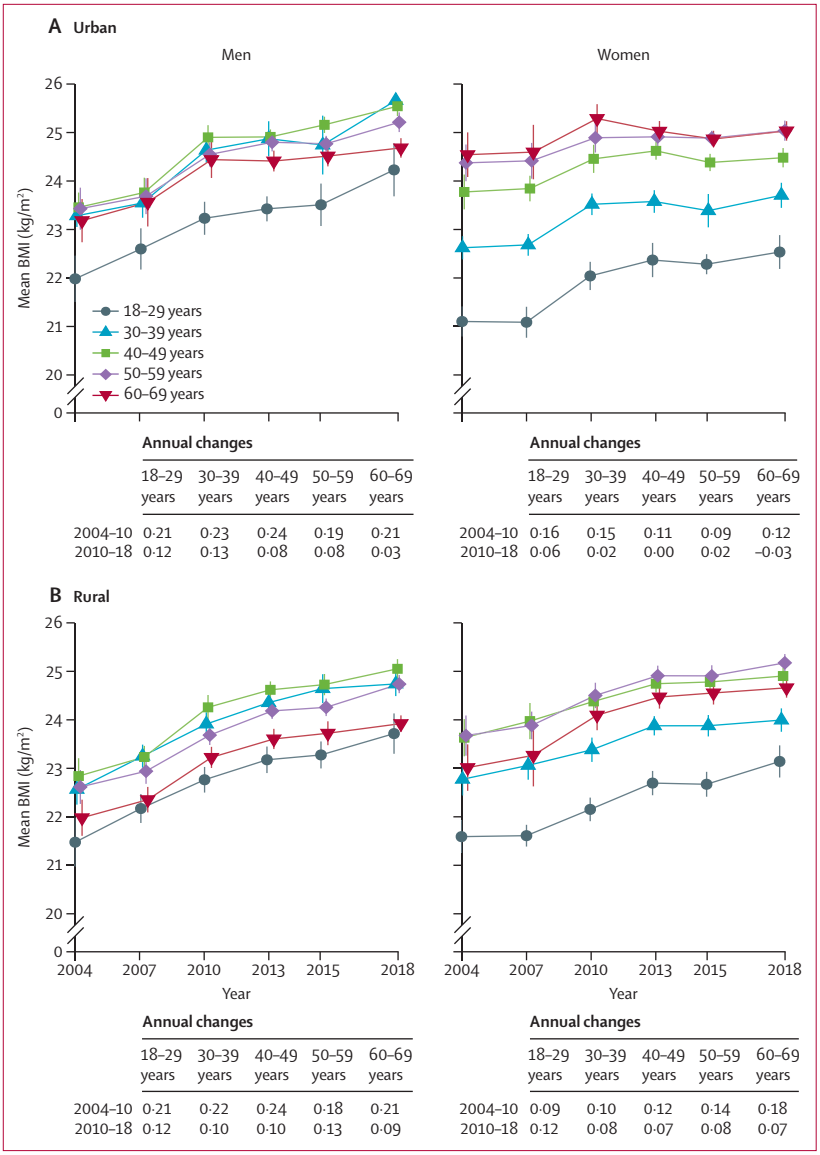


***Figure 2*: Standardised mean BMI in urban (A) and rural (B) areas from 2004 to 2018, by sex and age group**
Error bars show 95% CIs of the mean or prevalence. Results are standardised to the 2010 China census population. Annual change in mean BMI before and after 2010 are listed in the table in each panel. BMI=body-mass index.

and rural areas (figure 2; appendix p 13), except in urban areas the pace of increase in mean BMI and obesity slowed down more rapidly in older than in younger women (appendix p 26). In both sexes, the lowest mean BMI was in those aged 18–29 years (figure 2), whereas the lowest obesity prevalence was observed in the youngest age group in women but in the oldest age group in men (appendix p 13). Overall, among women mean BMI and obesity prevalence generally increased with age until about 50 years, with little further change afterwards. Among men, there was a more complex pattern, with middle-aged men (30–49 years) having the highest mean BMI and prevalence of obesity at each survey (figure 2; appendix p 13).

Between 2004 and 2010, the mean BMI and prevalence of obesity rose similarly in urban and rural areas, by about 0·17 kg/m² annually for mean BMI and 8–10% annually for obesity (figure 3; table 2). Over this period, men and women in urban areas had higher mean BMI and prevalence of obesity than did their rural counterparts (figure 3). However, after 2010 the trends diverged between urban and rural women. Among women in urban areas, the rise in mean BMI almost halted (increasing 0·03 kg/m² annually, 95% CI –0·01 to 0·07), whereas the rise among women in rural areas continued at 0·09 kg/m² annually (95% CI 0·05 to 0·12; table 2). However, among urban and rural men the rise in mean BMI continued, albeit at a slower rate compared with before 2010 (around 0·1 kg/m² annually). For obesity (as well as overweight), the annual rate of increase halved after 2010 compared with before 2010 in men (6·7%, 95% CI 4·2 to 9·2 *vs* 13·5%, 7·2 to 20·9; p=0·0400) and women (2·7%, 0·4 to 5·1 *vs* 6·3%, 0·8 to 12·8; p=0·1546). However, in rural areas, the situation appeared different after 2010, with the rise in obesity moderately slowing down in men (11·3%, 5·5 to 18·1 *vs* 7·5%, 5·0 to 10·1; p=0·1600) but continuing at a similar pace in women (5·6%, 0·7 to 11·0 *vs* 5·5%, 3·2 to 7·9; p=0·4983; table 2). Consequently, by 2018, women in rural settings had a higher mean BMI and obesity prevalence than did their urban counterparts (24·3 kg/m², 24·1–24·5 *vs* 23·9 kg/m², 23·6–24·1; p=0·0045; figure 3). Among men, a similar urban–rural switch has not taken place—men in rural settings had lower mean BMI than their urban counterparts in 2018 (24·5 kg/m², 95% CI 24·3–24·7 *vs* 25·1 kg/m², 24·8–25·3; p=0·0007)—partly due to a large increase in obesity among men in urban settings between 2015 and 2018. We did not observe divergent trends in the SDs of BMI between urban and rural women, suggesting that the larger rise in obesity in women in rural settings after 2010 was a population-wide phenomenon rather than a change among individuals with high BMI.

Between 2004 and 2018, the rise in mean BMI was larger among men and women with lower education than among those with higher education. However, we found no clear educational pattern for the rise in prevalence of obesity. The slowdown or plateauing in mean BMI and urban obesity since 2010 happened across all education groups, but the rise in rural obesity accelerated among women with secondary or higher levels of education (appendix pp 25–28).

In 2018, urban and rural men with the highest level of education had a mean BMI around 1·1 kg/m² higher and an obesity prevalence more than 100% higher than those with the lowest level of education (figure 4; appendix p 14). By contrast, urban and rural women with the highest level of education had lower mean BMI (by 1·6–1·8 kg/m²) and obesity prevalence (by 20–30%) than did those with the lowest level of education.

The trends in mean BMI and obesity prevalence were similar across different occupation groups (appendix pp 15–16). In both urban and rural areas, men doing non-manual work had a large rise in obesity prevalence between 2015 and 2018, but this was not evident among their female counterparts. Men working in agriculture-related professions had the lowest levels of obesity but women working in agriculture had similar levels of obesity to those working in other professions.

Trends in mean BMI and obesity prevalence were largely consistent across the seven geographical regions of China (appendix pp 17–18). A persistent north–south divide in both mean BMI and obesity prevalence was observed in men and women and in urban and rural areas. Overall, people living in northern China had a mean BMI more than 2 kg/m² higher than their counterparts in southern China. Likewise, there was more than three-times difference in obesity prevalence between northen China and southern China.

In sensitivity analyses involving 60 DSPs that were covered in all six surveys with no changes in geographical boundaries, we observed similar results to the main analyses, including a slowdown in urban BMI and obesity, with the exception of obesity in women in urban settings, which continued to rise at a similar pace since 2010 compared to before 2010 in these 60 DSPs (appendix p 19). Likewise, when using Chinese cutoff points to define obesity (≥28 kg/m²) and overweight (≥24 kg/m²), the results were generally similar to those based on the WHO definitions in the main analyses (appendix pp 31–32).

## Discussion

Using large-scale data from six nationally representative population surveys covering a period from 2004 to 2018, the present study showed that, although the prevalence of obesity has more than doubled and the total number of adults who were obese has more than tripled since 2004, there are divergent trends in urban and rural areas, especially among women. In urban China, the rise in adult BMI and obesity might be plateauing in women and slowing down in men, but in rural China continues to rise steadily, especially among women. These divergent trends led to higher mean BMI and obesity prevalence in women in rural settings compared with women in urban settings in 2018, with narrowing urban–rural difference among men. Across all six surveys, mean BMI was persistently lower in women with higher levels of education compared with women with lower levels of education, but the inverse was true among men, and geographically there were persistent north–south gradients in mean BMI and obesity prevalence.

Previous studies predicted a massive epidemic of obesity in China, based mainly on observations in other low-income and middle-income countries (LMICs).[6,28] For example, in Mexico, Brazil and Malaysia, mean BMI and obesity increased progressively to eventually surpass the levels seen in many high-income countries.[29–31] By contrast, the trends in BMI in China and the plateauing of BMI for women in urban settings are more in line with observations in high-income countries in east Asia (eg, Japan and South Korea) and western Europe (eg, France).[6,20,32–34] As in the present study, many LMICs and high-income countries have found BMI in rural populations to be rising faster than in urban areas;

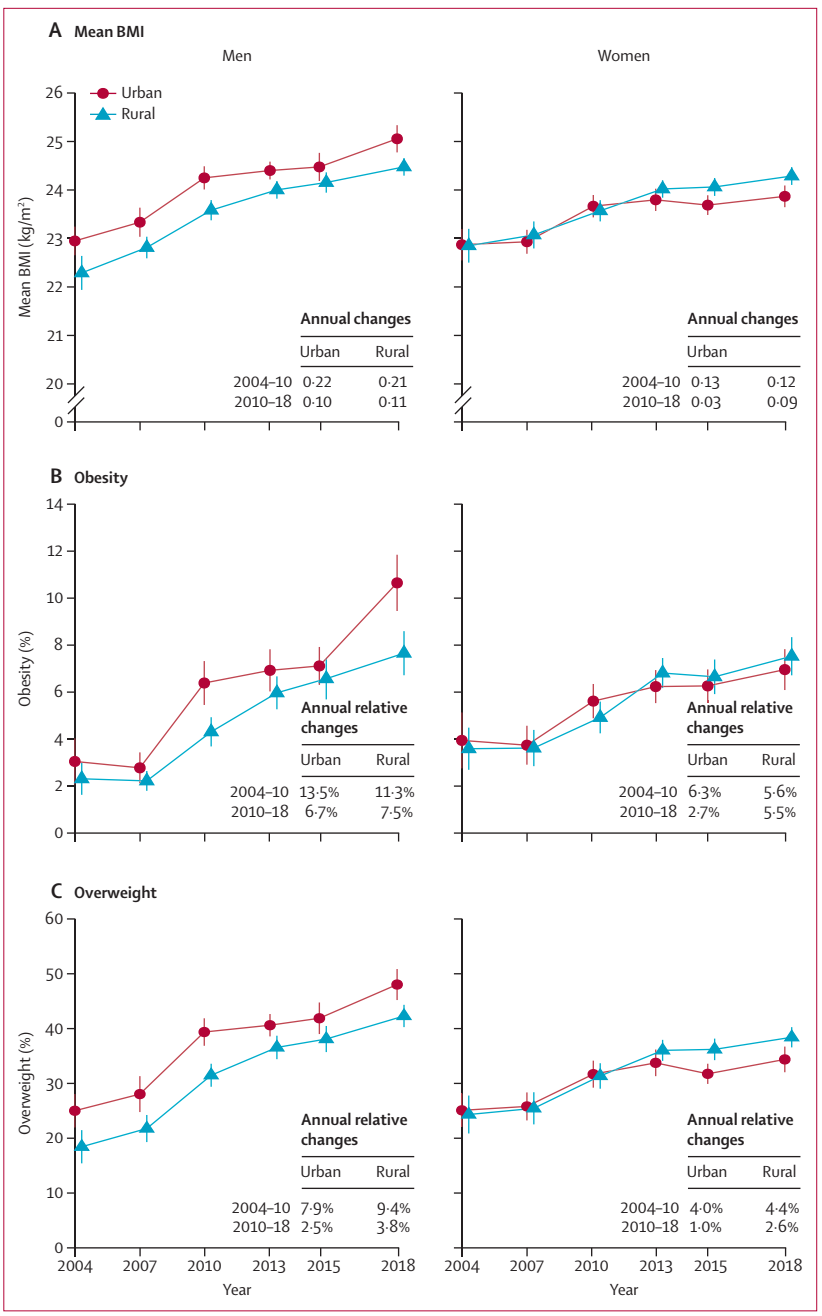


***Figure 3*: Standardised mean BMI (A), prevalence of obesity (B), and prevalence of overweight (C) from 2004 to 2018, by sex and urban–rural locality**

Error bars show 95% CIs of the mean or prevalence. Results are standardised to the 2010 China census population. Annual change in mean BMI and annual relative change in prevalence of obesity and overweight before and after 2010 are listed in the table in each panel. BMI=body-mass index.

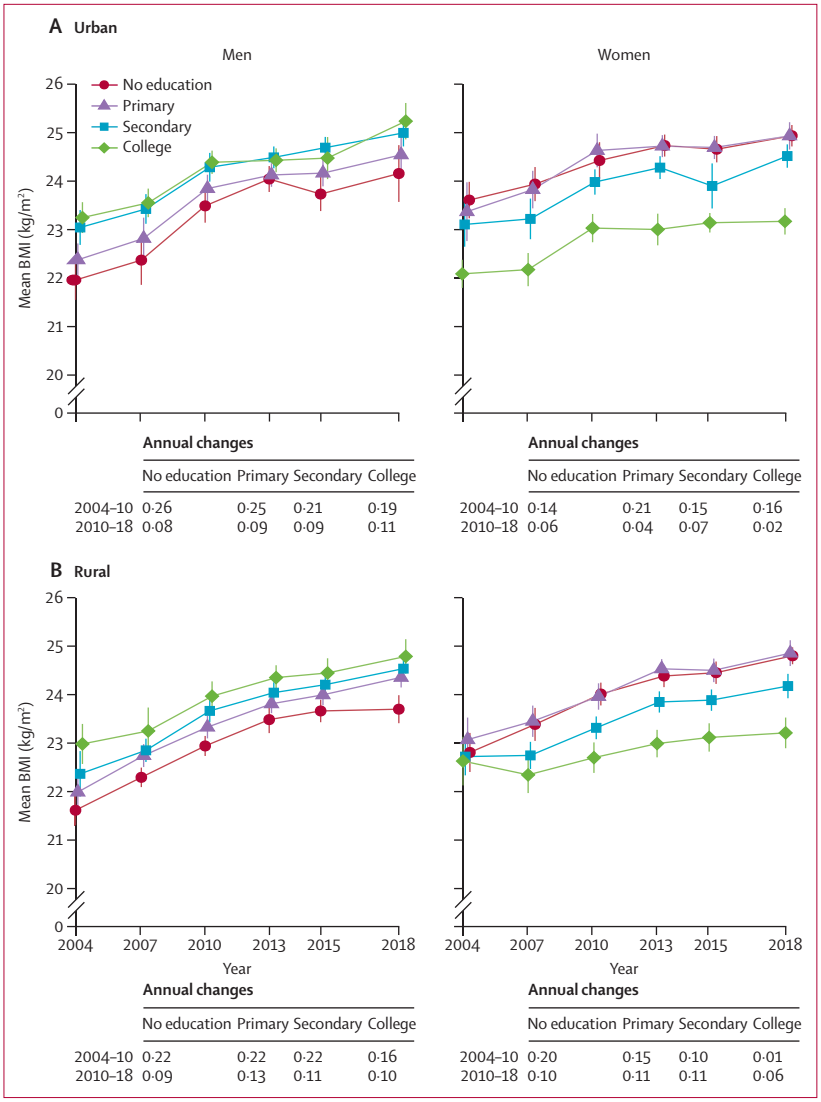


***Figure 4*: Standardised mean BMI in urban (A) and rural (B) areas from 2004 to 2018, by sex and level of education**

Error bars show 95% CIs of the mean or prevalence. Results are standardised to the 2010 China census population. Annual change in mean BMI before and after 2010 are listed in the table in each panel. BMI=body-mass index.

however, the urban–rural switch of female BMI, as observed in China, has been observed in high-income countries but is not evident in most other LMICs.[20] In many LMICs, including those in south and southeast Asia, BMI increased faster among women than men,[20] in contrast to our findings in China.

A few national studies have previously reported on the levels and trends in mean BMI and obesity prevalence in China. Both our early (pre-2010) and recent results (post-2010) were generally consistent with relevant findings in other studies at particular timepoints,[35–41] and a rising trend in BMI in general adult populations up to 2013.[12–19] Existing evidence on national trends beyond 2013 in China was mainly based on statistical models in global studies[6,20] or on studies that used an alternative cutoff to define obesity, which limited their comparability. A nationwide study, involving non-random sampling methods, reported a steady rise in mean BMI and prevalence of obesity (defined as BMI ≥27·5 kg/m²) among adults aged 18–80 years between 1993 and 2015.[21] In that study,[21] the annual increase in mean BMI (0·17 kg/m²) and obesity prevalence (12%) were similar to our results during 2004–10. In a study of more than 15 million married couples aged 49 years and younger in rural China who were planning pregnancy,[42,43] the reported prevalence of obesity (defined as BMI ≥28 kg/m²) in 2014 was lower than our findings using the same definition for both men (7% *vs* 14%) and women (5% *vs* 14%). The only study, to our knowledge, that reported trends after 2015 used data from two national surveys involving 426 000 adults aged 19 years and older from 31 provinces in China during 2013–18.[44] In that study,[44] the reported annual increases in prevalence of overweight (6%) and obesity (12%) using WHO definitions were greater than in our study (2% and 5%, respectively) during the same period. However, the obesity prevalence reported in that study for 2018 (3·7%) was noticeably lower than our results (8·1%), which was, as acknowledged in the paper, lower than other nationwide surveys and could have been due to inappropriate sampling methods (eg, 26% of participants were unemployed).[44] By analysing data from six consecutive surveys during 2004–18, our study provides robust new evidence about the evolving epidemic of obesity in China, not only overall but also regionally and by urban–rural locality.

Although a small number of studies in China have previously assessed the urban and rural trends in obesity and BMI separately, these studies did not identify the emerging divergent trends, mainly because of the time period covered.[14,17] The drivers underlying the increased and divergent trends in urban and rural China are complex, and might reflect differences in stages of economic development, changing levels and patterns of physical activity, and increases in total calorie intake and consumption of animal-based food.[45–47] In China, despite an overall increase in leisure-time physical activity since 2000,[48] total physical activity declined sharply from 1991 to 2009, especially in rural areas.[49] Our study also showed that the proportion of people working in agricultural and manual occupations decreased from 60% in 2004 to 38% in 2018. Even among those in agricultural jobs, increased use of machines might also have reduced the level of physical activity involved. Throughout the study period, although income has been increasing steadily in both urban and rural China,[50] rural residents might have spent disproportionately more of their increased income on food than urban residents, having initially had lower incomes. With higher income and a large rise in packaged and processed foods in both rural and urban areas,[51] the composition of the Chinese diet is changing, generally moving towards higher intake of fat and animal products.[52–54] There is evidence that

people with higher levels of education and those in more urbanised areas have higher scores for healthy eating,[55] and economically more developed urban areas have seen greater improvement in diet quality in recent decades.[56] Data from the UN Food and Agriculture Organization also showed a large increase in daily calorie supply and the proportion from animal sources and sugar in China during this period.[57,58]

The contrasting education gradients in BMI and obesity between men and women observed in our study are consistent with two smaller studies in China that used non-nationwide samples in multiple provinces.[59,60] Previous studies in high-income or upper-middle-income countries also reported similar findings among women, but mixed results among men,[61] with little high-quality data from other LMICs.[62] Our study provides reliable evidence concerning the contrasting associations of education with BMI and obesity between men and women, but further studies are needed to elucidate contributing factors.

Apart from the large sample size and nationally representative samples covering the period from 2004 to 2018, the main strengths of our study include high response rates, use of largely consistent protocols over time, and the ability to assess trends by sex, urban–rural locality, geographical region, and socioeconomic status. However, our study also has limitations. First, the surveys were not done annually, which could have allowed more detailed and quantitative analysis of the plateauing or slowdown in trends, which will be monitored and assessed in future surveys. Second, the number of DSPs covered across different surveys, hence sampling scheme and study size, changed over time, potentially introducing bias in the observed trends. Nevertheless, in our sensitivity analyses of 60 areas that were included in all six surveys, the results were similar to our main analyses. Third, although the instruments used for measuring height and weight have not changed since 2007, a different model was used in 2004, which might affect the comparability of data with later rounds of the survey. Despite this change, both devices can measure weight reliably and there were regular calibrations in field surveys to ensure data quality. Fourth, our sample had a smaller proportion of men (42–47%) compared with the 2010 census population (50%); this is because, as is commonly done in household surveys, our surveys only sampled individuals who had been living at the same address for at least 6 months in the past 12 months. Therefore, people who worked away from their home address were not eligible to participate, which would disproportionately affect men working in certain occupations, such as construction, compared with women, and affect the representativeness of the study population. To minimise the effect of this, we used the sex-specific 2010 census population to estimate the overall results.

In conclusion, the present study provides robust new evidence about the evolving epidemic of obesity among adult populations in China. Although the rise in mean BMI among adults appears to have slowed down during the past decade, there were divergent trends between urban and rural areas, contrasting associations of education with adiposity in men and women, and large variations in obesity prevalence across different regions. As China continues to modernise and become more urbanised, obesity and the associated health burdens (eg, hypertension and diabetes) are likely to become more and more of an issue in rural areas in the coming decades. Our study findings highlight the need to continue to monitor the longer-term trends nationally and regionally, and for a better understanding of the factors underlying these trends to develop more targeted and effective prevention strategies in both urban and rural China.[63]

#### Contributors

LimW, XL, ZC, ME, GD, and JW developed the study concept and drafted the analyses plan. LimW, XL, GD, JW, ZZ, MeiZ, YJ, YL, MaiZ, LinW, ZH, XZ, LZ, and DY collected the data. ZZ, BZ, and MeiZ did the analysis and prepared the results. BZ, ZZ, LY, ZC, and ME wrote the first draft of the paper. All authors provided input into interpretation of the results and content of the paper. LimW, JW, and XL had full access to all of the data in the study and verified the data, and are responsible for the integrity and accuracy of the data and the decision to submit the manuscript.

#### Declaration of interests

We declare no competing interests.

#### Data sharing

Individual participant data in our study will not be made available publicly. For further detailed data access policy and procedure, please contact jianceshi@ncncd.chinacdc.cn.

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