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Secular trend and projection of overweight and obesity among Chinese children and adolescents aged 7–18 years from 1985 to 2019: Rural areas are becoming the focus of investment

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Abstract

Background: The urban–rural disparities in overweight and obesity among children and adolescents are narrowing, and there is a need for long-term and updated data to explain this inequality, understand the underlying mechanisms, and identify priority groups for interventions.

Methods: We analyzed data from seven rounds of the Chinese National Survey on Students Constitution and Health (CNSSCH) conducted from 1985 to 2019, focusing on school-age children and adolescents aged 7–18 years. Joinpoint regression was used to identify inflection points (indicating a change in the trend) in the prevalence of overweight and obesity during the study period, stratified by urban/rural areas and sex. Annual percent change (APC), average annual percent change (AAPC), and 95% confidence interval (CI) were used to describe changes in the prevalence of overweight and obesity. Polynomial regression models were used to predict the prevalence of overweight and obesity among children and adolescents in 2025 and 2030, considering urban/rural areas, sex, and age groups.

Results: The prevalence of overweight and obesity in urban boys and girls showed an inflection point of 2000, with AAPC values of 10.09% (95% CI: 7.33–12.92%, $t = 7.414$, $P <0.001$) and 8.67% (95% CI: 6.10–11.30%, $t = 6.809$, $P <0.001$), respectively. The APC for urban boys decreased from 18.31% (95% CI: 4.72–33.67%, $t = 5.926$, $P = 0.027$) to 4.01% (95% CI: 1.33–6.75%, $t = 6.486$, $P = 0.023$), while the APC for urban girls decreased from 13.88% (95% CI: 1.82–27.38%, $t = 4.994$, $P = 0.038$) to 4.72% (95% CI: 1.43–8.12%, $t = 6.215$, $P = 0.025$). However, no inflection points were observed in the best-fit models for rural boys and girls during the period 1985–2019. The prevalence of overweight and obesity for both urban and rural boys is expected to converge at 35.76% by approximately 2027. A similar pattern is observed for urban and rural girls, with a prevalence of overweight and obesity reaching 20.86% in 2025.

Conclusions: The prevalence of overweight and obesity among Chinese children and adolescents has been steadily increasing from 1985 to 2019. A complete reversal in urban–rural prevalence is expected by 2027, with a higher prevalence of overweight and obesity in rural areas. Urgent action is needed to address health inequities and increase investments, particularly policies targeting rural children and adolescents.

Keywords: Children and adolescents; Overweight; Obesity; Urban–rural inequality; Prevalence; Prediction

Introduction

Childhood and adolescent overweight and obesity have undergone a rapid and substantial increase in recent decades, posing a significant global public health concern.[1–3] The global prevalence of obesity increased to 10% for boys and 8% for girls in 2020,[4] which has enormous negative impact on health outcomes of individuals with obesity and great economic burdens for societies.[5] In view of the global emergency caused by childhood obesity, the member states of the World Health Organization (WHO) have endorsed "no increase in childhood overweight by 2025" as one of the six global nutritional goals.[6] However, thus far, no country has managed to achieve a reduction in obesity prevalence across their entire population.[4]

Given the escalating prevalence of overweight and obesity among children and adolescents aged 7–18 years, it soared

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from 5.3% in 1995 to 24.2% in 2019 and affected almost a quarter of children and adolescents in China.[7] China has become the country with the largest number of children and adolescents suffering from overweight and obesity in the world.[4,8] Research has indicated potential variations in the patterns of urban–rural disparities in the nutritional status of children and adolescents across developed and developing countries.[9–11] Most developing countries, including China, are witnessing a trend of diminishing urban–rural gaps in overweight and obesity, and some regions in China, particularly those experiencing rapid economic growth, even exhibit a phenomenon known as "urban–rural reversal".[12–14] Building upon these findings, it is essential to develop targeted interventions for overweight and obesity in China and other low- and middle-income countries undergoing rapid economic and social transformations.[15]

Hence, based on the 1985–2019 survey data of the Chinese National Survey on Students Constitution and Health (CNSSCH), the largest nationally representative sample of school-aged children and adolescents in China, we aimed to assess the evolving trends and provide future projections regarding the prevalence of overweight and obesity among children and adolescents aged 7–18 years. Moreover, we sought to identify specific target populations for intervention strategies.

Methods

Data sources

Data were extracted from CNSSCH in 1985, 1995, 2000, 2004, 2010, 2014, and 2019. The study exclusively included Han Chinese children and adolescents aged 7–18 years from 30 provinces, autonomous regions, and municipalities in China (Excluding Hong Kong, Macao, Taiwan, and Xizang). Among them, there were no data for Hainan and Chongqing in 1985 and no data for Qinghai and Chongqing in 1995. Chongqing was not a municipality until 1997 and did not participate in the survey before. In this study, the sample sizes for the years 1985, 1995, 2000, 2005, 2010, 2014, and 2019 were 409,946, 204,932, 216,334, 234,421, 215,319, 214,354, and 212,713, respectively. Informed consent was obtained from the participants and their guardians. This study was approved by the Peking University Biomedical Ethics Committee (No. IRB00001052-19095).

Overweight and obesity measurement and definition

Height and weight measurements were conducted following standardized protocols, administered by trained personnel and subjected to stringent quality control measures under the supervision of research supervisors. According to the International Obesity Task Force (IOTF) criteria, overweight was defined as body mass index (BMI) ≥85th percentile and obesity was defined as BMI ≥95th percentile for sex- and age-specific groups[16]. We employed the IOTF growth curve criteria as a steady benchmark to guarantee the comparability of our data through the 34-year timeframe of our research. This standardized measure allows us to track overweight and

obesity trends in China over time with better accuracy, as it reduces inconsistencies that might arise from shifting diagnostic criteria across different periods.

Statistical analysis

To identify priority target groups, the study categorized children and adolescents into four groups based on urban/rural areas and sex: urban boys, urban girls, rural boys, and rural girls. Furthermore, considering the age intervals and corresponding school stages, children and adolescents between the ages of 7 years and 18 years were divided into four groups: 7–9 years, 10–12 years, 13–15 years, and 16–18 years. The Mantel–Haenszel trend test was used to calculate the P values for trend values by different groups.

Joinpoint regression analysis was performed using Joinpoint software version 4.8.0, developed by the Division of Cancer Control and Population Sciences at the US National Cancer Institute.[17] This involved constructing piecewise regression models based on the temporal patterns of overweight and obesity distribution, utilizing log-linear models within the Joinpoint regression framework. Monte Carlo permutation tests were employed to determine the statistically significant number of joinpoints, identifying the optimal fitting model. The joinpoints' positions within the optimal model delineated inflection points in the long-term trends of the indicators. The key outcome measures derived from the Joinpoint regression model were the annual percent change (APC), average annual percent change (AAPC), and their corresponding 95% confidence intervals (CIs). The APC represented the average annual percentage change in overweight and obesity within different segments, while the AAPC indicated the overall average percent change in the trend of overweight and obesity over time. The APC was employed to assess the trend within each segment of a specific time period when inflection points were present. In contrast, the AAPC served as an indicator of the trend spanning a fixed interval, regardless of the existence of inflection points. In the absence of an inflection point, the APC and AAPC values would indeed be equivalent.

Polynomial regression models were used with year as the independent variable and the prevalence of overweight and obesity as the dependent variables to analyze the trends from 1985 to 2019. The models were used to predict the prevalence of overweight and obesity for children and adolescents in different subgroups (urban/rural areas, sex, and age groups) for the years 2025 and 2030. Apart from the Joinpoint regression analysis, all other analyses were conducted using R version 4.2.0 (R Development Core Team, Vienna, Austria). Two-sided tests were used with a significance level of $\alpha = 0.05$.

A sensitivity analysis was conducted to assess the accuracy and reliability of screening for overweight and obesity utilizing an alternative definition outlined by the National Health Commission of China in 2018.[18] This analysis aimed to examine the impact of the prevalence and projection of overweight and obesity using different criteria in the study population.

Results

Sociodemographic characteristics of children and adolescents

The study included a total of 1,708,019 children and adolescents from 1985 to 2019. The sample distribution across urban/rural areas, sex, and age groups was relatively balanced in each year. Over the study period, the prevalence of overweight and obesity among children and adolescents aged 7–18 years in China exhibited a substantial increase. The prevalence of overweight and obesity rose from 0.69% (2825/409,946) to 20.45% (43,500/212,713), representing a 28.68-fold increase. In terms of obesity alone (excluding overweight), the prevalence increased from 0.03% (133/409,946) to 5.03% (10,696/212,713), which translates to a staggering 153.99-fold increase [Table 1].

Secular trends of overweight and obesity

The results of the Joinpoint regression analysis revealed that the AAPC for the prevalence of overweight and obesity among Chinese children and adolescents was 10.25% (95% CI: 7.30–13.27%, $t = 7.064$, $P < 0.001$) from 1985 to 2019 [Figure 1A]. During this period, its best-fit model had an inflection point in 2000, indicating a change in the trend. The APC for the prevalence of overweight and obesity was 15.96% (95% CI: 1.93–31.93%, $t = 4.941$, $P = 0.039$) from 1985 to 2000, and the upward trend slowed down after 2000, with an APC of 5.94% (95% CI: 2.73–9.24%, $t = 8.084$, $P = 0.015$). Similar to the overall population, both boys and girls in urban areas exhibited an inflection point in 2000, and the AAPC was 10.09% (95% CI: 7.33–12.92%, $t = 7.414$, $P < 0.001$) and 8.67% (95% CI: 6.10–11.30%, $t = 6.809$, $P < 0.001$), respectively. Similarly, the APC values decreased after 2000, with urban boys having an APC of 4.01% (95% CI: 1.33–6.75%, $t = 6.486$, $P = 0.023$) and urban girls having an APC of 4.72% (95% CI: 1.43–8.12%, $t = 6.215$, $P = 0.025$) compared to the initial APCs of 18.31% (95% CI: 4.72–33.67%, $t = 5.926$, $P = 0.027$) and 13.88% (95% CI: 1.82–27.38%, $t = 4.994$, $P = 0.038$), respectively. In contrast, no inflection points were observed for rural boys

and rural girls between 1985 and 2019. The AAPC for overweight and obesity prevalence among rural boys was 10.17% (95% CI: 7.29–13.13%, $t = 9.404$, $P < 0.001$), and for rural girls, it was 9.17% (95% CI: 8.14–10.20%, $t = 23.893$, $P < 0.001$).

As depicted in Figure 1B, the AAPC for obesity prevalence in children and adolescents was 14.74% (95% CI: 8.34–21.52%, $t = 4.697$, $P < 0.001$). During this period, its best-fit model identified an inflection point of 2000. Between 1985 and 2000, the APC for the prevalence of obesity was 23.48% (95% CI: –6.84 to 63.65%, $t = 3.221$, $P = 0.084$). However, after 2000, the rate of increase slowed down, with an APC of 8.29% (95% CI: 4.35–12.37%, $t = 9.251$, $P = 0.011$). Similar to the overall population, urban boys had an inflection point of 2000, with an AAPC of 14.05% (95% CI: 9.83–18.43%, $t = 6.839$, $P < 0.001$), and a decline in APC from 25.00% (95% CI: 3.90–50.40%, $t = 5.191$, $P = 0.035$) to 6.09% (95% CI: 3.56–8.67%, $t = 10.541$, $P = 0.009$). In contrast, no inflection points were observed in the best-fit models for urban girls, rural boys, and rural girls. The AAPCs for obesity prevalence in these groups were 8.48% (95% CI: 5.45–11.60%, $t = 7.375$, $P < 0.001$), 12.68% (95% CI: 9.86–15.56%, $t = 12.135$, $P < 0.001$), and 12.31% (95% CI: 9.48–15.21%, $t = 11.689$, $P < 0.001$), respectively, for the entire period of 1985–2019.

Our findings indicated that the prevalence of overweight and obesity demonstrated an inflection point roughly around the year 2000 in 3 age groups, including 6–9 years, 10–12 years, and 13–15 years. However, when considering the prevalence of obesity alone, an inflection point was featured exclusively within the span of adolescents aged 10–12 years [Supplementary Figure 1, http://links.lww.com/CM9/C2].

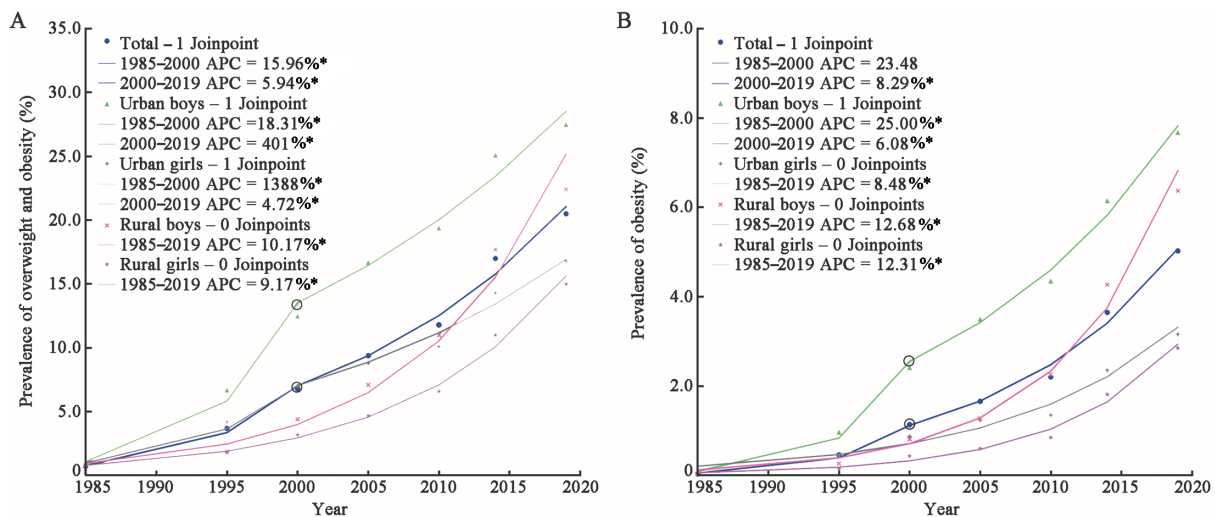### Projection of overweight and obesity

From 1985 to 2019, the prevalence of overweight and obesity increased significantly among urban boys, urban girls, rural boys, and rural girls. In 1985, the prevalence rates were 0.91%, 0.90%, 0.25%, and 0.70%, respectively. By 2019, these rates had risen to 27.54%, 16.78%,

Table 1: Characteristics of children and adolescents in each survey.

| Parameters	1985 (n = 409,946)	1995 (n = 204,932)	2000 (n = 216,334)	2005 (n = 234,421)	2010 (n = 215,319)	2014 (n = 214,354)	2019 (n = 212,713)	χ^2	P-trend
Urban/rural area								0.147	0.702
Urban	204,727 (49.94)	103,741 (50.62)	108,673 (50.23)	117,997 (50.34)	107,574 (49.96)	107,239 (50.03)	106,706 (50.16)		
Rural	205,219 (50.06)	101,191 (49.38)	107,661 (49.77)	116,424 (49.66)	107,745 (50.04)	107,115 (49.97)	106,007 (49.84)		
Sex								0.045	0.833
Boys	205,100 (50.03)	103,102 (50.31)	108,147 (49.99)	117,680 (50.20)	107,687 (50.01)	107,216 (50.02)	106,703 (50.16)		
Girls	204,846 (49.97)	101,830 (49.69)	108,187 (50.01)	116,741 (49.80)	107,632 (49.99)	107,138 (49.98)	106,010 (49.84)		
Age groups (years)								19.611	<0.001
7–9	102,678 (25.05)	49,148 (23.98)	54,150 (25.03)	58,111 (24.79)	53,837 (25.00)	53,702 (25.05)	53,916 (25.35)		
10–12	102,715 (25.06)	52,259 (25.50)	54,275 (25.09)	58,478 (24.95)	53,904 (25.03)	53,771 (25.09)	53,937 (25.36)		
13–15	102,695 (25.05)	51,953 (25.35)	53,833 (24.88)	58,466 (24.94)	53,863 (25.02)	53,861 (25.13)	53,310 (25.06)		
16–18	101,858 (24.85)	51,572 (25.17)	54,076 (25.00)	59,366 (25.32)	53,715 (24.95)	53,020 (24.73)	51,550 (24.23)		
Overweight and obesity	2825 (0.69)	7534 (3.68)	14,693 (6.79)	21,932 (9.36)	25,382 (11.79)	36,493 (17.02)	43,500 (20.45)	92459.798	<0.001
Obesity	133 (0.03)	938 (0.46)	2454 (1.13)	3889 (1.66)	4744 (2.20)	7823 (3.65)	10,696 (5.03)	23765.951	<0.001

Data are represented as *n* (%).

Figure 1: Joinpoint regression analysis on prevalence of overweight and obesity (A), obesity alone (B) among children and adolescents aged 7–18 years in China from 1985 to 2019, by urban/rural areas and sex. *Indicates that the APC is significantly different from zero at the alpha = 0.05 level. APC: Annual percent change.

22.40%, and 14.98%, respectively, marking a substantial increase over the span of 34 years. The prevalence rates in 2019 were 29.40 times, 17.68 times, 88.47 times, and 20.31 times higher than the rates in 1985 for urban boys, urban girls, rural boys, and rural girls, respectively. Likewise, the prevalence of obesity also demonstrated a considerable rise. In 1985, the obesity prevalence rates were 0.06%, 0.04%, 0.01%, and 0.02% for urban boys, urban girls, rural boys, and rural girls, respectively. By 2019, these rates had increased to 7.69%, 3.16%, 6.38%, and 2.85%, indicating increases of 128.09 times, 76.00 times, 502.59 times, and 171.02 times over the 34-year period, respectively [Figure 2].

Using a polynomial regression function prediction model, it was projected that the prevalence of overweight and obesity among children and adolescents would continue to rise. By 2025 and 2030, the prevalence of overweight and obesity is estimated to reach 26.88% and 32.67%, respectively, with the prevalence of obesity reaching 6.89% in 2025 and 8.78% in 2030. The prevalence of overweight and obesity for urban and rural boys is projected to reach the same level of 35.76% approximately in 2027, after which the rural boys will overtake the urban boys. Furthermore, it is estimated that by 2030, the prevalence of overweight and obesity in urban boys and rural boys will reach 38.43% and 40.82%, respectively, and the prevalence of obesity will reach 12.36% and 12.19%, respectively. Similar trends can be observed among girls in urban and rural areas. The prevalence of overweight and obesity is projected to reach the same level (20.86%) by 2025, with the prevalence of obesity reaching the same level (4.86%) approximately in 2028, after which rural girls will surpass urban girls. By 2030, it is estimated that the prevalence of overweight and obesity among urban girls and rural girls will be 24.61% and 26.76%, respectively. The prevalence of obesity is expected to reach 5.23% among urban girls and 5.32% among rural girls.

From 2014 to 2019, there was a slight decrease in the prevalence of overweight and obesity among urban boys
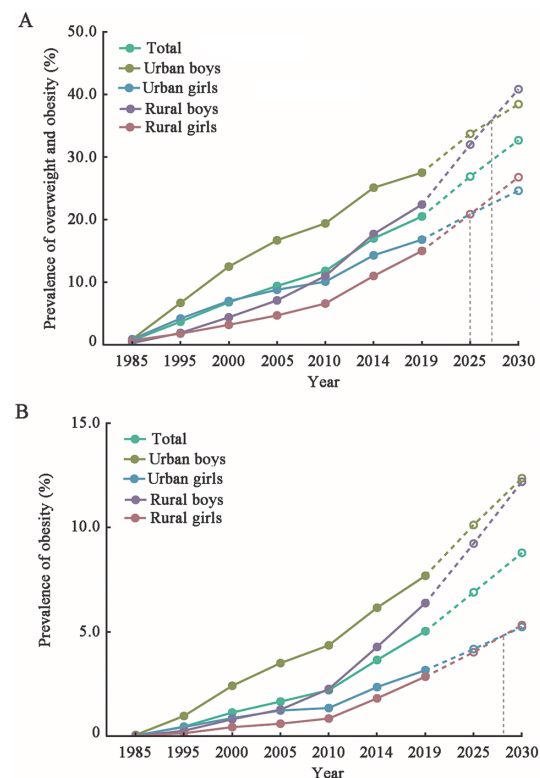
Figure 2: Prevalence and projection of overweight and obesity (A), obesity alone (B) among children and adolescents aged 7–18 years in China from 1985 to 2019, by urban/rural areas, and sex. Dotted line indicates the year in which the same prevalence reached.

and girls aged 7–9 years old. The prevalence of obesity among urban girls followed a similar pattern [Figure 3]. Among children and adolescents aged 10–12 years, they were the main contributors to the high prevalence of overweight and obesity between 1985 and 2019. In terms of obesity, the main contributing group shifted from children and adolescents aged 6–9 years to 10–12 years among urban boys and girls in 2019. However, among rural boys and girls, the main contributor group remained
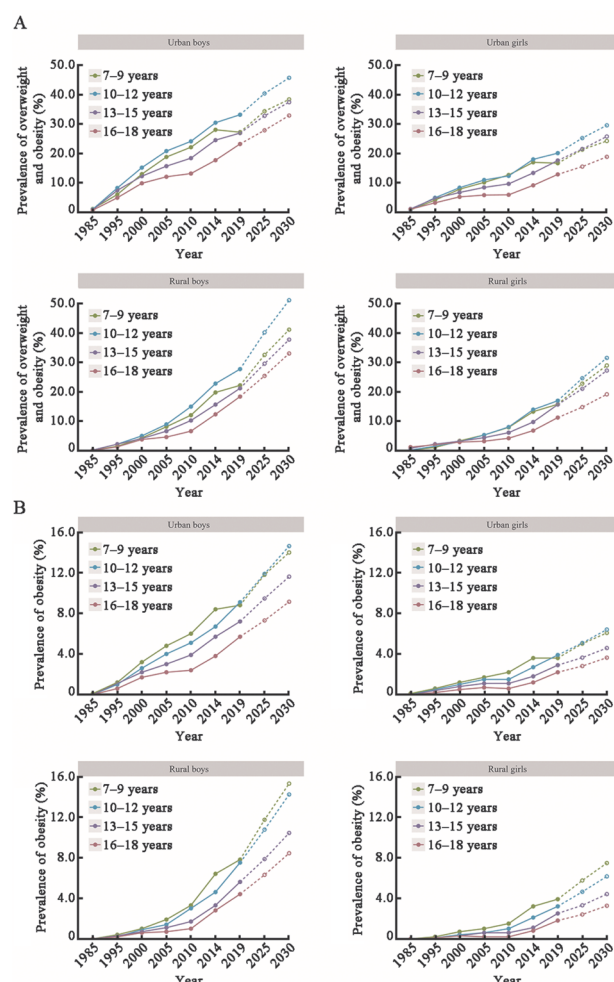
Figure 3: Prevalence and projection of overweight and obesity (A), obesity alone (B) among children and adolescents aged 7–18 years in China from 1985 to 2019, by urban/rural areas, sex, and age groups.

7–9 years old. This indicates that the gap in the prevalence of obesity between different age groups will gradually widen. The prevalence of overweight and obesity was found to be similar by using both the IOTF criteria and Chinese criteria. However, the prevalence of obesity was much lower when using the IOTF criteria compared with the Chinese criteria, but with similar projection patterns [Supplementary Figure 2, http://links.lww.com/CM9/C2].

Discussion

This study observed a continuous increase in the prevalence of overweight and obesity among children and adolescents from 1985 to 2019. Notably, there was an inflection point in 2000, after which the growth rate of overweight and obesity slowed down. Moreover, from 2014 to 2019, there was a slight decline in the prevalence of overweight and obesity among urban boys and girls aged 7–9 years. Projections indicate that the prevalence of overweight and obesity among rural children and adolescents will surpass that of their urban counterparts by 2027, marking a reversal in the trend. It is worth noting that the prevalence of overweight and obesity was more concentrated among children and adolescents in

the younger age group, and those aged 10–12 years have emerged as a new focal point of concern.

The prevalence of overweight and obesity among Chinese children and adolescents is currently experiencing a rapid and continuous increase. These findings are in line with previous studies[14,15] and have been extended to encompass a nationally representative sample in 2019. The rapid growth of childhood obesity has long-term consequences, as it contributes to a cumulative population of obesity in adulthood. This, in turn, has significant implications for population health, human capital, and the healthcare burden in China. It was estimated that the losses due to overweight and obesity in China would reach 1.9–3.1% of the gross domestic product from 2020 to 2035.[19] Additionally, the issue of overweight and obesity appears to have been further exacerbated by the impact of the coronavirus disease 2019 (COVID-19) pandemic and the subsequent national lockdown.[20–23] While China has implemented a series of new policies to prevent and control childhood and adolescent obesity since 2014, it is crucial to urgently validate the effectiveness of their implementation through the generation of new datasets and further studies.

The present study found that the APC in the prevalence of overweight and obesity among urban boys and girls in China started to slow down in 2000. The identified inflection point shows a slowdown in the spread of overweight and obesity issues and chronic public health challenges, potentially influenced by pivotal events or policy execution in certain years. This observation in urban areas served as an indication of the possible effectiveness of policies that were rolled out around the year 2000, such as the notice of "Further Strengthening the Management of the Prevention and Control of Common Diseases among Students in 1999",[24] the "Chinese National Survey on Students Constitution and Health Monitoring Network Work Program (Trail)" in 1999,[25] and the implementation of the "Student Milk Drinking Program" in 2000.[26] However, this phenomenon was not observed among rural boys and girls, suggesting that the previous policies primarily benefited children and adolescents in urban areas, with limited impact in rural areas.

Since then, to curb the continuous growth of overweight and obesity among children and adolescents, China has also introduced a series of policies to control obesity among children and adolescents, such as the "China Food and Nutrition Development Program (2014–2020)" in 2014,[27] the "Healthy China 2030" planning outline in 2016,[28] the "Implementation Program for Prevention and Control of Childhood and Adolescent Obesity" in 2020,[29] and the "Outline of China's Child Development Program (2021–2030)" in 2021.[30] These policies might have contributed to the decline in the prevalence of overweight and obesity among urban boys and girls aged 7–9 years from 2014 to 2019. Evidence has suggested that policy interventions are sustainable and cost-effective measures for addressing obesity.[31] Nevertheless, there is still a need for research focusing on childhood and adolescent obesity at the policy level, as studies in this area remain limited according to the Socio-Ecological Model

(SEM).[32] It is still necessary to increase relevant periodic policy research to evaluate the effects of relevant policies and to make timely policy adjustments for health equity.

The rapid increase in overweight and obesity in rural areas is leading to a future scenario of "urban–rural reversal". This shift could be attributed to rapid economic development, which has narrowed the gap between urban and rural areas. Urban children and adolescents have easier access to high-energy foods and lack physical activity, both of which are major risk factors for overweight and obesity. However, with socioeconomic development, rural children and adolescents may face similar risks.[14] In high-income countries, such as the United States,[33,34] the United Kingdom,[35] and Australia,[36] rural children and adolescents have been at higher risk of overweight and obesity compared with their urban counterparts. Moreover, since 2000, average BMI has stabilized, often at high levels, in many high-income countries, while continuing to rise in low- and middle-income countries.[8] The prevalence of overweight and obesity among urban children and adolescents in developing countries, including China, is higher than that in rural areas. However, the gap between urban and rural areas is gradually narrowing until some or all areas reach the levels seen in developed countries.[14] For example, Beijing and Shandong in eastern China have already witnessed the reversal of the "urban–rural gap" in overweight and obesity among children and adolescents.[37] Over time, children and adolescents in economically underdeveloped rural regions of China may experience higher levels of overweight and obesity. Therefore, there is an urgent need to adjust obesity-related policies and increase investment in the health of rural children and adolescents.

It is evident that the status of overweight and obesity in younger children tends to accumulate and persist as they transition into older age groups. Research has shown that approximately 80% of adolescents aged 10–14 years and 50% of children aged 6–9 years with obesity maintain this status into adulthood.[38] In addition, the onset of puberty, typically occurring between the ages of 10 years and 12 years, has been found to be associated with obesity in previous studies.[39] Moreover, a review has also suggested that prevention programs yield the best outcomes when targeting younger children, specifically those below the age of 12 years.[40] Moreover, the inflection point analysis conducted in different age groups in this study found that the age group of 10–12 years old may contribute the most to the slowing down of overweight and obesity prevalence. Considering the significance, necessity, and feasibility, the findings of this study further underscore the need to take proactive and timely interventions to prevent overweight and obesity in younger children. It is crucial to initiate interventions as early as possible to mitigate the long-term consequences and health risks associated with obesity throughout adolescence and into adulthood.

This study does have certain limitations that should be acknowledged. Specifically, the IOTF criteria utilized in this research were found to be less sensitive in identifying obesity in Chinese children and adolescents.[16] This equivalence to the adult cutoff points for overweight and obesity contributes to a higher threshold for obesity detection. As a result, there is a possibility that the prevalence and projection of obesity in this population might have been underestimated in children and adolescents. However, it is worth noting that the IOTF criteria were highly specific in identifying populations with obesity who are in urgent need of interventions. This specificity could prove valuable in optimizing and prioritizing health resources and interventions to target those most in need.

In conclusion, the prevalence of overweight and obesity in Chinese children and adolescents exhibited a consistent upward trend from 1985 to 2019. Moreover, it is anticipated that a complete reversal in the prevalence between urban and rural areas will occur by 2027, indicating that the prevalence of overweight and obesity in rural areas is expected to surpass that in urban areas. This calls for urgent measures to reduce health disparities and increase investments, particularly in terms of policy initiatives aimed at addressing the health needs of rural children and adolescents. Furthermore, interventions targeted at younger children and adolescents remain a crucial focal point. It is essential to continuously push the boundaries of obesity prevention and control efforts to effectively combat this public health concern.

Conflicts of interest

None.

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