

REVIEW ARTICLE

Trends in overweight and obesity among children and adolescents aged 5 to 19 years living in rural areas of low- and middle-income countries: a systematic review

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ABSTRACT

The issue of overnutrition in rural areas has often been overshadowed by the focus on urbanization and modernization as the main drivers. Therefore, with this systematic review we aimed to determine trends in overweight and obesity among children and adolescents living in rural areas of low- and middle-income countries (LMICs). We conducted a comprehensive search of MEDLINE and Web of Science, from inception to 06 August 2023. Cross-sectional observational studies reporting on overweight and obesity in children and adolescents living in rural areas of LMICs were independently reviewed by several researchers. Simple linear regression was used to analyze trends in overweight and obesity over time. This study is registered on PROSPERO (CRD42023444823). In total, 176 studies from 132 publications, involving 697,395 participants were analyzed. The prevalence of overweight and obesity increased significantly between 1985 and 2022 ($P=0.04$ for overweight, $P=0.09$ for obesity). Subgroup analysis showed a significant increase in the prevalence of overweight and obesity in the East Asia and Pacific region, as well as in middle-income countries, from 1985 to 2021 ($P<0.01$). The findings of our study highlight the escalating rates of overweight and obesity among children and adolescents in rural areas of LMICs, particularly in East Asia and the Pacific and middle-income countries. Our study emphasizes the urgent need to address this public health challenge to reduce the risks associated with childhood overweight and obesity in rural areas.

Keywords:

overweight; obesity; overweight and obesity; children; adolescents; childhood obesity; rural; LMICs

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INTRODUCTION

The increasing prevalence of overweight and obesity among children and adolescents is a global public health concern in the 21st century. The World Health Organization (WHO) has reported that more than 390 million children and adolescents aged 5 to 19 years were overweight or obese in 2022.¹ Obesity in children and adolescents is associated with obesity,^{2,3} diabetes,³⁻⁶ cancer,^{4,7} coronary heart disease,⁸ and other cardiometabolic outcomes^{4,5} in adulthood.

In low- and middle-income countries (LMICs), conditions associated with childhood malnutrition, such as wasting and stunting, related to limited macro- and micro-nutrients, have traditionally been a major concern. However, since the late 1990s, attention has increasingly been paid to the increases observed in overweight and obesity.^{9,10} A review found that in some LMICs the prevalence of overweight, including obesity, among children aged 5 to 19 years between 1974 and 2010 was 10%, varying from 4.1% in 1974 to 27.9% in 2010.¹⁰ As decreases in physical activity, as well as the nutrition transition, driven by urbanization and modernization, are considered to be the main factors contributing to the increase in overnutrition,¹¹⁻¹³ overweight and obesity have often been perceived as problems primarily affecting those living in urban areas. However, the NCD Risk Factor Collaboration has reported that the increase in average body mass index (BMI) in

individuals living in rural areas, between 1985 and 2017, is the primary factor contributing to the global obesity epidemic among adults.¹⁴ Recent studies have also shown that overweight and obesity among children, adolescents, and young adults are more prevalent in rural areas of some high-income countries, such as the United States (US),¹⁵ Japan,¹⁶ Sweden,¹⁷ Australia,¹⁸ and Greece.¹⁹ For instance, a meta-analysis of 74,168 children aged between 2 and 19 years in the US found that children living in rural areas had 26% higher odds of obesity compared with children living in urban areas.¹⁵ A trend analysis involving 11 national school-based health surveys conducted in Greece from 1997 to 2008 showed that the prevalence of obesity among children in urban areas increased from 7.2% to 11.3% for girls and from 8.1% to 12.4% for boys, while in rural areas, it increased from 7% to 13% for girls and from 8.2% to 14.1% for boys.¹⁹ However, there has been a lack of research into overweight and obesity specifically in rural areas of LMICs.

Thus, in this study, we aimed to determine trends in the prevalence of overweight and obesity among children and adolescents living in rural areas of LMICs. By addressing this research gap, our study will contribute to an interdisciplinary understanding of this issue and provide valuable insights for future investigations.

METHODS

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.²⁰ The protocol of the review is registered on PROSPERO (CRD42023444823).

Search strategy

The initial search was performed (by MS) using two major electronic databases: MEDLINE (via PubMed) and Web of Science, from their inception to 6 August 2023. A comprehensive search strategy was conducted using the following keywords: (1) population: “child”, “children”, “school children”, “adolescents”, “childhood”; AND (2) outcome 1: “overweight”, “obesity”, “obese”, “nutritional status”, “body size”; AND (3) outcome 2: “prevalence”, “rate”, “incidence”; AND (4) countries: names of all LMICs, (Supplementary Table SI1). LMICs were selected based on the World Bank Country and Lending Groups²¹ classification, as of the date of the search.

Inclusion and exclusion criteria

Only cross-sectional observational studies published in English were included in this review. Inclusion criteria were (1) school- or population-based studies; (2) studies targeting the general population; (3) studies reporting the outcomes of interest

(prevalence of overweight, obesity, BMI, or BMI z-scores) in rural areas (if it was not stated whether the study site was rural or urban, the study site was considered to be rural if it had a population of less than 50,000 or if 80% of the population lived in rural areas; (4) studies targeting children or adolescents aged 5 to 19 years; (5) studies reporting the prevalence of overweight and obesity or mean BMI or BMI z-score. Studies that did not meet the inclusion criteria were excluded.

Data collection and extraction

Following the literature search, the list of identified articles was saved in Microsoft Excel, and any non-relevant articles were excluded based on their titles, abstracts, or full-text (MS). Selected articles were reviewed by at least two members of the research team (MS, GS, TM, SA, AN), who independently assessed the articles for their eligibility. The same team members performed data extraction, entering the data into another Excel spreadsheet. Following data extraction, another team member double-checked the accuracy of the extracted data. The information extracted from the papers included:

- Authors and year of publication
- Year of data collection
- Survey/dataset name (for secondary studies)
- Study location (country and region)

- Other classifications (if any)
- Sample size from rural areas (in cases where a paper only mentioned the proportions of sample size from urban areas and rural areas, the sample size was calculated by the authors using the total sample size)
- Age of participants
- Indicators of overweight/obesity used and references for the indicators
- Prevalence of overweight/obesity in rural areas
- Mean BMI/BMI z-score in rural areas
- Whether the studies compared the prevalence of overweight and/or obesity between rural and urban populations

If a paper did not report the year of data collection, MS sent emails to the authors of the papers querying this (n=24, response rate 42%). Any disagreements that arose during this process were resolved through the discussion between the authors.

Quality assessment

We assessed the quality of the included papers using the Newcastle–Ottawa scale,²² which was adopted for cross-sectional studies in a previous review.²³ We modified it for this review, considering the purpose of this study. The assessment was based on three criteria: selection, comparability, and outcome. The modified scale used in this review can be found in the Supplementary Information S1. Each extracted paper was accessed by at least two team members.

Statistical analysis

Prior to our analysis, papers were excluded if (1) data were duplicated with other papers; (2) rural sample size was not reported; (3) anthropometric measurements were not performed; (4) sample size was less than 20; (5) year of data collection was unknown; or (6) the quality of a paper was considered low based on the quality assessment (Supplementary Information S1). The Mantel–Haenszel test was used to calculate the common odds ratio of overweight and obesity between urban and rural populations. Studies without sufficient data to calculate the number of overweight or obese participants were not subjected to the test. Simple linear regression was used to examine trends in the prevalence of overweight and obesity, as well as BMI and BMI z-scores. Subgroup analyses were conducted based on regions and income levels, to better understand the diversity within LMICs, enhance the quality of our analysis by revealing nuanced trends, and facilitate international comparisons by providing context for obesity trends across different socioeconomic backgrounds. Statistical analyses were conducted using R version 4.3.2 (<http://www.R-project.org/>), with a significant level of 0.05.

RESULTS

Literature search

The search identified 10,779 unique articles from the two databases and an additional source identified during the

review. After excluding articles based on their titles and abstracts, 2,962 full-text articles were screened, leaving a total of 220 cross-sectional studies for data extraction. After extracting data, 88 articles were

excluded for the reasons described in the statistical analysis section, which left a total of 132 studies for analysis. Figure 1 shows the flow chart of the PRISMA article selection process.

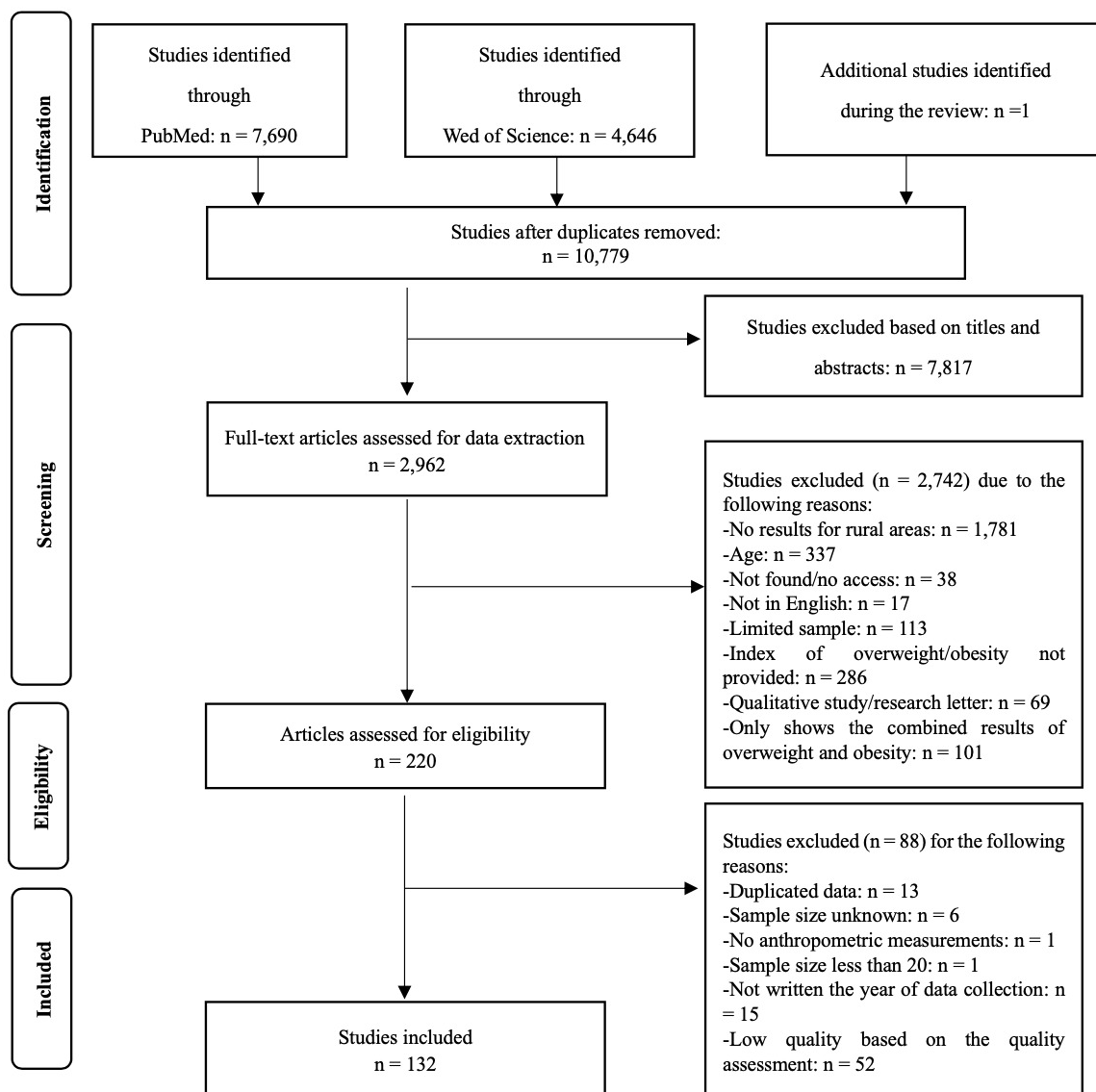


Figure 1. PRISMA flow chart of the study selection procedure

General overview of included reviews

Supplementary Table SI2 shows the complete references and characteristics of the articles included. A total of 176 studies were extracted from 132 articles, representing 42 countries. The datasets included a total of 697,395 participants aged 5 to 19 years, with sample sizes ranging from 44 to 59,649. The median score of quality assessment was 5 out of 7, which is considered medium quality. The most used indicators of overweight and obesity were the WHO BMI z-score,²⁴ the International Obesity Task Force (IOTF) BMI,²⁵ and the US Centers for Disease Control and Prevention (CDC) BMI z-score,²⁶ although country- and region-specific indicators were also used. Table SI3 shows the results of the studies included.

Comparison with urban counterparts

A total of 67 articles compared the results of rural residents with those of their urban counterparts. Supplementary Figures SI1, SI2, and SI3 show the adjusted odds ratio for overweight in males, females, and combined genders living in urban environments, yielding pooled odds ratios of 1.78 (95% confidence interval (CI) 1.35 to 2.34), 1.55 (95% CI 1.28 to 1.89), and 1.74 (95% CI 1.51 to 2.01), respectively ($P < 0.001$). Supplementary Figures SI4, SI5, and SI6 illustrate the adjusted odds ratio for obesity in males, females, and combined genders living in urban environments, resulting in pooled odds ratios of 2.00 (95% CI 1.48 to 2.69), 1.91 (95% CI 1.38 to 2.65),

and 2.29 (95% CI 1.90 to 2.76), respectively ($P < 0.001$). However, it is noteworthy that the results varied among studies, given the considerable heterogeneity for each test.

Trends in overweight and obesity from 1985 to 2022**Prevalence of overweight and obesity**

A considerable number of studies reported the prevalence of overweight and obesity for males and females separately ($n=60$ and 61 , respectively, for males and $n=66$ and 67 , respectively, for females), while a majority included combined outcomes ($n=91$ and 96 , respectively). Supplementary Table SI3 shows the results of our simple linear regression analysis. There were statistically significant changes in the prevalence of both overweight and obesity, with the prevalence increasing from 1985 to 2022. However, these significant changes were only found in the combined results ($P=0.04$ for overweight, $P=0.009$ for obesity), and there was no statistically significant change in either male or female results separately.

BMI and BMI z-scores

Less than a quarter of the studies provided BMI data for males ($n=37$) and females ($n=40$) separately, with 50 studies reporting combined outcomes. The results of our simple linear regression are shown in Supplementary Table SI3. There was a statistically significant increase in mean BMI for males ($P=0.026$), while no significant changes were observed for the other groups.

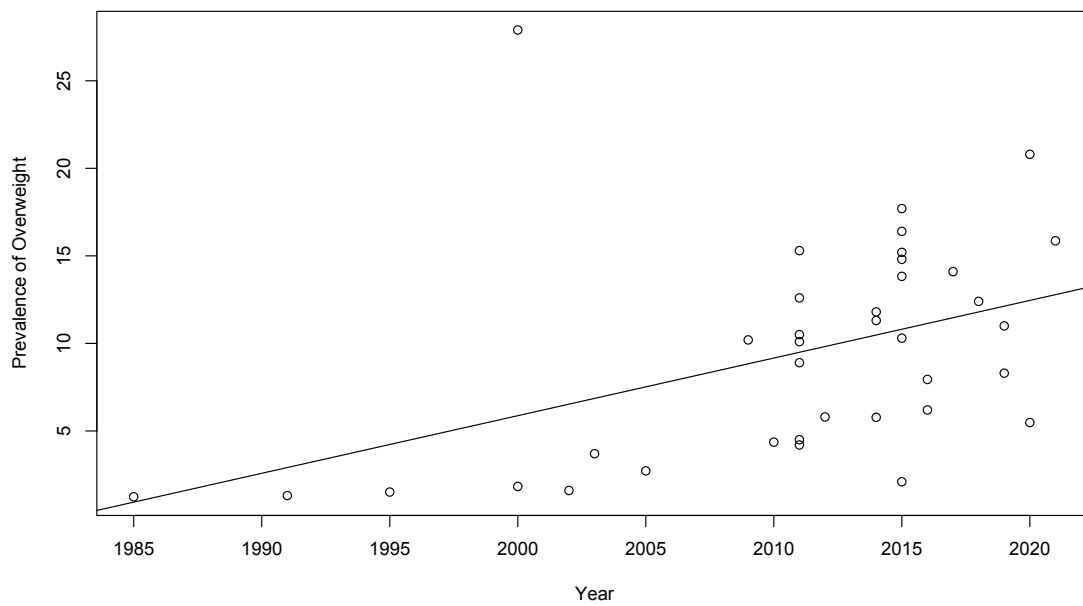


Figure 2. Trend in the prevalence of overweight in the East Asia and Pacific region

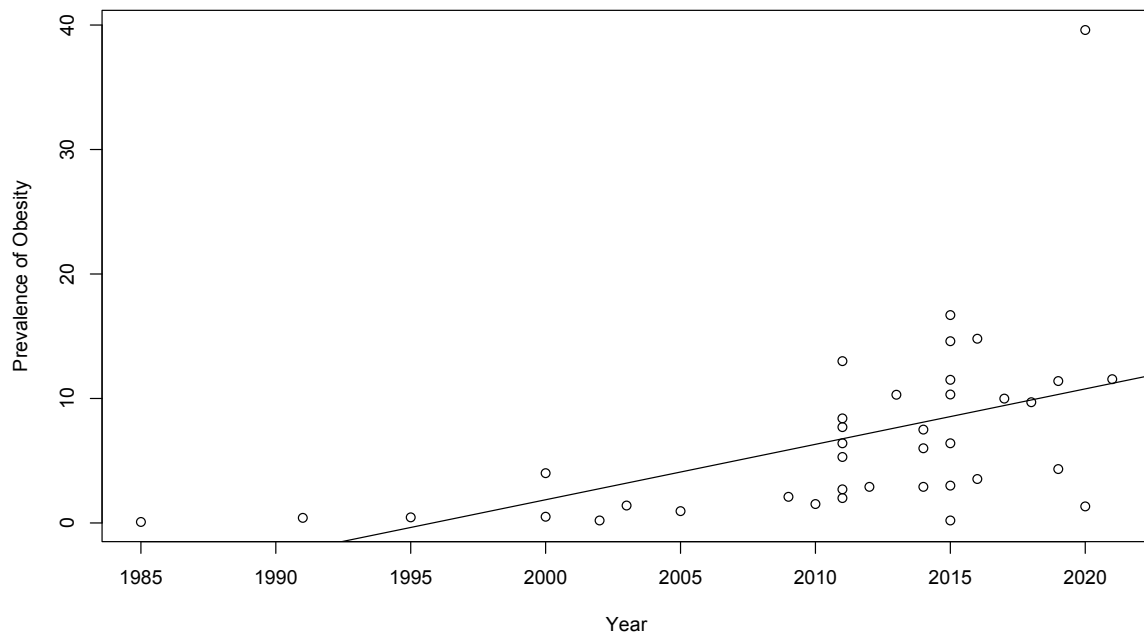


Figure 3. Trend in the prevalence of obesity in the East Asia and Pacific region

Region

Most data were collected in the East Asia and Pacific region (n=55), followed by Latin America and the Caribbean (n=39), sub-Saharan Africa (n=37), South Asia (n=23), Europe and Central Asia (n=11), and the Middle East and North Africa

(n=11). Statistically significant increases in the combined prevalence of overweight and obesity were observed in the East Asia and Pacific region (both $P < 0.01$), but not in other regions. Figures 2 and 3 show the trend in the prevalence of overweight and obesity in the East Asia and Pacific region.

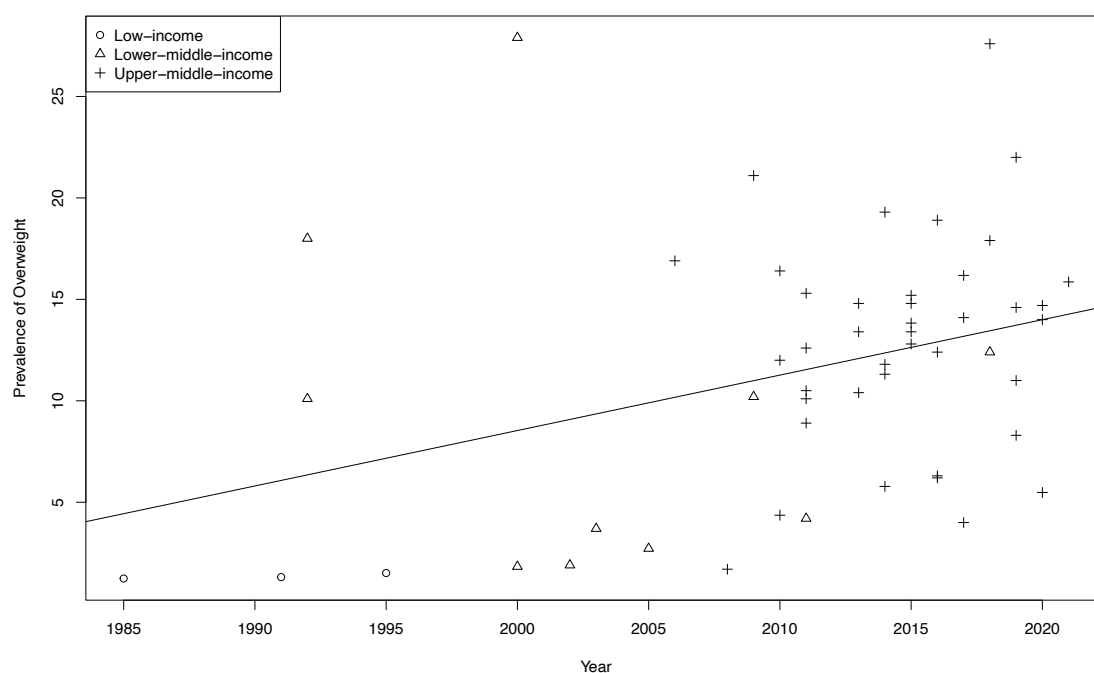


Figure 4. Trends in the prevalence of overweight in upper-middle-income countries showing the income level during the respective survey years

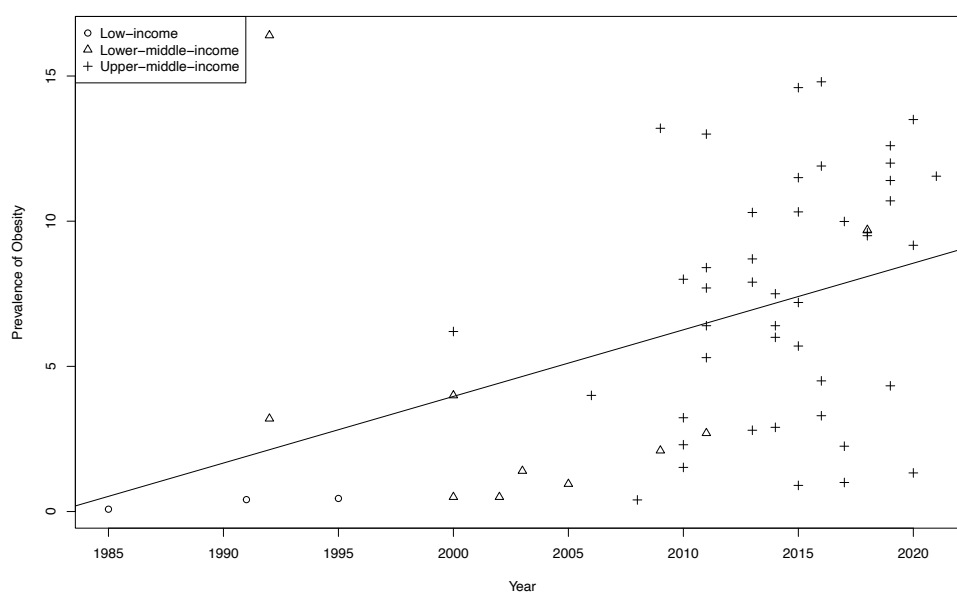


Figure 5. Trends in the prevalence of obesity in upper-middle-income countries showing the income level during the respective survey years

Income level

Most countries belonged to the upper-middle-income category (n=113), with 58 classified as lower-middle-income and 5 as low-income. Given the limited number of studies in low-income countries, low- and lower-middle-income countries were combined for this analysis. In low- and lower-middle-income countries, there was no statistically significant change in the combined prevalence of overweight or obesity. In contrast, there were statistically significant increases in the combined prevalence of overweight and obesity in upper-middle-income-countries ($P>0.01$ for both overweight and obesity).

Supplementary Figures SI7 and SI8 illustrate the change in the prevalence of overweight and obesity in both low- and lower-middle-income countries and upper-middle-income countries. It is noteworthy that the prevalence of overweight and obesity appears to be higher in upper-middle-income countries compared with low- and lower-middle-income countries. Figures 4 and 5 depict trends in the prevalence of overweight and obesity in upper-middle-income countries, with an indication of the income level of the country at the time of data collection.

DISCUSSION

This systematic review provides a comprehensive picture of trends in the prevalence of overweight and obesity in children and adolescents aged 5 to 19 years living in rural areas in LMICs from 1985 to 2022. To our knowledge, this is the first study to focus specifically on children and adolescents living in rural areas in these countries.

Overall trend in overweight and obesity

One of the main findings of this study was that the overall prevalence of overweight and obesity in children and adolescents increased significantly between 1985 and 2022. The prevalence of overweight and obesity in the included studies varied, as shown in Table SI3, with the earliest observation year in 1985 reporting 1.24% and 0.08%, respectively, and the most recent in 2022 reporting 25% and 6.03%, respectively.^{27,28} The highest prevalence of overweight and obesity during the period was 27.9% in 2000 and 39.6% in 2020, which were observed in the Kingdom of Tonga²⁹ and Vietnam, respectively.³⁰ Similar increasing trends, in agreement with this result, have been observed in other studies. Yang et al. also found that the prevalence of overweight and obesity in rural areas in China increased from 1.24% to 8.30% and from 0.08% to 4.33%, respectively, between 1985 and 2019.²⁷ The results of our study are also consistent with results from China,³¹ Bangladesh,^{32,33} Iran,³⁴ Brazil,³⁵ and Turkey.³⁶ However, some of these studies included non-rural populations, and research focusing specifically on rural populations remains limited in LMICs.

Trends in overweight and obesity in the East Asia and Pacific region

Another notable finding of our study was that there was a significant increase in overweight and obesity rates in the East Asia and Pacific region, while no significant increase was found in other regions. The countries included in the East Asia and Pacific region for this analysis were China, Vietnam, Kingdom of Tonga, Malaysia, Thailand, Indonesia, and Cambodia. As shown in Figures 2 and 3, the prevalence of overweight and obesity has increased since 2010. Results from the South East Asian Nutrition Survey,

conducted between 2010 and 2011, which were also included in this systematic review, highlighted the double burden of malnutrition, which is the coexistence of undernutrition and overnutrition, in rural areas at the regional level during the period. In Indonesia and Vietnam, undernutrition was observed to be the greatest problem.^{37,38} Conversely, in Thailand, the prevalence of underweight, stunting, and thinness was not significantly different from the prevalence of overweight and obesity.³⁹ Moreover, the prevalence of overweight and obesity (12.6% and 13.0%, respectively) was higher than that of thinness (9.3%) in Malaysia.⁴⁰ Similarly, studies conducted in Malaysia and Vietnam in 2015 also reported that the prevalence of overweight was higher than that of thinness in rural areas.^{41,42} Based on these findings, it is reasonable to assume that the prevalence of overweight and obesity increased after 2010, with overnutrition surpassing undernutrition in the region thereafter. In Cambodia, however, the prevalence of overweight and obesity was just 2.1% and 0.2%, respectively, compared with the high prevalence of stunting and thinness (36.4% and 16.1%) in 2015.⁴³ This may be due to the lower income level of Cambodia compared with other countries in the region.

Throughout the study period, there has also been a change in the urban–rural difference among the nutritional status of children and adolescents in the region: the prevalence of overweight and obesity in rural areas has not only become comparable with that seen in urban areas but in some cases has even exceeded that of urban areas.^{39,44–47} The reason for the trend in overnutrition in the region during this period may be explained by the nutrition transition resulting from modernization and more open trade markets, bringing social and economic development.⁴⁸ In China, for example, it was reported in 2004 that diets were shifting from traditional foods to high energy-density, high fat, low fiber diets.⁴⁹

Between 1991 and 2011, among children living in less urbanized areas, the consumption of edible oils and animal-based foods increased, while the consumption of coarse grains and legumes decreased.⁵⁰ The percentage of calories from boiled, steamed, or baked foods and those prepared at home decreased, but the percentage of calories from snacks and foods prepared away from home increased.⁵⁰ This finding may have been related to the increase in the number of small convenience stores or grocery stores that source foods and beverages directly from manufacturers in rural areas during those years.⁵⁰ There was also a dramatic increase in snacking habits over the same period.^{51,52} An increase in sales of carbonated beverages, oils, and fats was also reported in Asian countries such as Vietnam, Indonesia, China, Malaysia, and Thailand between 2000 and 2017.⁵³ These studies indicate that the food system in middle-income Asian countries has undergone a rapid transformation due to the increase in sales of ultra-processed foods and the expansion of modern food retail channels. Also, the increase in fast food sales is likely to be a major upstream driver of the food transition in the region. Similar changes in traditional dietary patterns and an increase in the dependence on imported food were also observed in the Pacific region.⁵⁴

Trends in overweight and obesity in upper-middle-income countries

Our study also found a significant increase in the prevalence of overweight and obesity in upper-middle-income countries. The following countries, classified as upper-middle-income countries, reported the prevalence of overweight and/or obesity: Russia, China, Turkey, the Kingdom of Tonga, Mexico, Mauritius, South Africa, Brazil, Malaysia, Thailand, Indonesia, Colombia, Costa Rica, Armenia, Peru, and Montenegro. In 1985, the earliest observation year, the prevalence

of overweight and obesity was 1.24% and 0.08%, respectively, while in 2021, the most recent year, these proportions had increased to 15.86% and 11.55%, respectively.^{27,55} Figures 4 and 5 show that most of these countries were classified as lower-middle-income countries between 2000 and 2010, and the prevalence of overweight and obesity was not particularly high during this period. However, after 2010, many of these countries experienced economic growth and were reclassified as upper-middle-income countries; this economic growth might have contributed to the increase in the prevalence of overweight and obesity. Given that many countries in the East Asia and Pacific region are classified as upper-middle-income countries, it is reasonable to assume that they exhibit the same tendency as observed in this study. Indeed, another study has illustrated that rapid economic growth and subsequent urbanization have had a considerable impact on the incidence of obesity and its associated comorbidities in many countries, including LMICs.⁵⁶ This trend has been further exacerbated by globalization, which has increased access to low-cost, nutrient-poor, energy-dense foods, as well as processed and convenience foods and sugar-sweetened beverages, all of which have contributed to the global obesity pandemic.⁵⁶ In some lower-middle-income-countries, the sales of frozen products (kg), snacks (kg), and soft drinks (l) per capita increased by 0.06 kg, 0.10 kg, and 1.10 l per year, respectively, from 1998 to 2012.⁵⁷ The rate of increase in the consumption of soft drinks and processed foods, as well as tobacco and alcohol, has increased at a faster rate in LMICs than in high-income countries during this period.⁵⁸ At the same time, modernization has led to declines in physical activity during leisure time, transportation, and work, which has also

played a considerable role in the increased prevalence of obesity around the world.⁵⁹ A cross-sectional study of 19,298 university students from 23 countries found that the prevalence of inactivity during leisure time was 44% in developing countries, which was higher than in developed countries.⁶⁰

Urbanization and the increasing prevalence of overweight and obesity

Between 1985 and 2023, LMICs have experienced ongoing urbanization. As countries undergo economic development and urban centers expand, the distinction between urban and rural living becomes less pronounced. Globally, the prevalence of overweight and obesity is on the rise, and the urban–rural obesity gap appears to be narrowing, primarily due to the increasing prevalence of overweight individuals among rural populations. While the prevalence of overweight is increasing in both rural and urban areas, this increase is more pronounced in many rural populations, which may explain the upward trend in overweight and obesity observed since 2010.⁶¹

Limitations and strengths of this study

This study had several limitations. First, the number of studies conducted before 2000 was relatively small, potentially limiting the depth of analysis for earlier periods. Second, the restriction of the literature search to papers written in English may have introduced language bias and limited the generalizability of the results. Third, while all included studies were conducted in rural areas, variations in living environments and socioeconomic status across different regions may have introduced heterogeneity in the data. Fourth, the use of different indexes and references for defining overweight and obesity across studies, such as WHO, IOTF, and CDC may have led to

inconsistencies that could have affected the comparability of results. Lastly, the initial screening was performed by one author, so some papers could have been missed.

Despite these limitations, this systematic review also had several notable strengths. First, this study addressed an often-overlooked issue by focusing on children aged 5 to 19 years living in rural areas, providing valuable insights into the trends of overweight and obesity among this group in LMICs. Second, the analysis was based on a comprehensive dataset comprising 176 studies and 697,395 participants, enhancing the reliability and generalizability of the findings. Third, by including a wide range of literature, potential bias was minimized. Lastly, the subgroup analysis highlighted specific regional trends, particularly in the East Asia and Pacific region and among middle-income countries, underscoring the necessity for targeted public health interventions in these areas. Overall, this study emphasizes the urgent need to address the escalating rates of overweight and obesity among children and adolescents in rural areas of LMICs, providing critical information for policymakers and public health practitioners.

RECOMMENDATIONS

This study highlights the urgent need for targeted interventions to address the increasing prevalence of overweight and obesity among children and adolescents in rural areas of LMICs, specifically in the East Asia and Pacific region and among middle-income countries. Potential strategies could include school-based interventions, awareness programs for children and their parents or caregivers, and relevant policy development. However, it will also be essential to prioritize further research to investigate the specific factors contributing to overweight and obesity in each

community, including socioeconomic and sociocultural determinants, as well as the impact of food systems, to better understand which interventions are most effective.

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