

Longitudinal Assessment Of Childhood Obesity Risk Factors In Urban School Populations

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Abstract

Background: Childhood obesity is on the rise in urban areas, attributed to sedentary lifestyles, unhealthy eating practices and socioeconomic disparities among school-aged children. **Objective:** To longitudinally assess the main risk factors of childhood obesity and their impact on the evolution of body mass index (BMI) in urban school populations over a five-year period. **Methodology:** A longitudinal cohort study was conducted on 5,000 students aged 6-14 years from 20 urban schools. We collected data on demographic characteristics, diet, physical activity, screen time, sleep duration and socioeconomic status each year. Statistical analyses were conducted using mixed-effects regression models to identify significant predictors for obesity and machine learning models were developed for obesity risk prediction. **Results:** At 5 years, the prevalence of obesity increased from 14.8% at baseline to 21.6%. The most significant risk factors were low physical activity (OR = 2.86, $p < 0.001$), high screen time (OR = 2.41, $p < 0.001$) and frequent intake of sugary beverages (OR = 1.94, $p < 0.01$). **Conclusion:** The findings confirm the critical role of behavioral and socioeconomic factors in the progression of childhood obesity. Promoting physical activity, healthy nutrition and reduced sedentary behavior through early school-based interventions are important to reduce the risk of obesity in urban school populations.

Keywords: Childhood Obesity, Urban Schools, Longitudinal Study, Risk Factors, Body Mass Index, Physical Activity, Screen Time, Machine Learning, Public Health, Obesity Prediction

1. Introduction

Childhood obesity has become one of the most serious public health problems of the 21st century, in both developed and developing countries. Recent global estimates indicate that the prevalence of overweight and obesity among children and adolescents has increased substantially over the last few decades, with the highest rates of increase being in urban populations due to rapid socio-economic and lifestyle transitions [1]. Urbanization has changed dietary patterns, increased consumption of energy-dense processed foods, decreased physical activity, and increased sedentary behaviors such as watching television, playing video games, and using smartphones [2].

Childhood obesity has many health consequences, both short-term and long-term. Excess body weight leads to cardiovascular diseases, hypertension, insulin resistance, type 2 diabetes, metabolic syndrome, respiratory disorders and musculoskeletal complications [3]. Childhood obesity may also have psychological and social consequences, such as low self-esteem, anxiety, depression, and social stigmatization, which may extend into adulthood [4]. There is evidence that childhood obesity often persists into adolescence and adulthood, increasing the burden on healthcare systems and reducing overall quality of life [5].

Several studies have identified multiple factors contributing to childhood obesity, including genetic predisposition, unhealthy dietary habits, insufficient physical activity, socioeconomic inequalities, environmental influences and behavioral factors [6]. Within these, physical inactivity and excessive screen time have been consistently reported as major contributors to weight gain in school-aged children [7]. Urban environments may further increase the risk of obesity due to limited access to recreational areas, increased exposure to marketing of unhealthy foods, and disparities in neighborhood resources [8].

Previous cross-sectional studies provided valuable insights into prevalence and associated factors of obesity but often had limited ability to capture temporal changes in the obesity trajectories and risk-factor progression. Longitudinal studies provide a more comprehensive understanding of how behavioral, environmental and demographic characteristics influence the development of obesity over time [9]. Evidence of this type is vital for the development of targeted interventions and public health policies for the prevention of childhood obesity in urban school populations.

The present study aims to analyze longitudinal trends in obesity among urban school children, to identify important behavioural, environmental, and demographic risk factors, to evaluate predictive models for obesity risk prediction, and to provide evidence-based recommendations for intervention strategies. More specifically, the study aims to answer the following research questions: (i) What are the most important factors causing childhood obesity development? (ii) What are the dynamics of obesity trajectories over time in urban school populations? (iii) Do predictive models accurately identify children at high risk for obesity? The major contributions are a multi-year longitudinal obesity assessment, a comprehensive risk-factor analysis, a predictive modelling framework for obesity risk stratification, and policy recommendations for urban school health initiatives [10].

Figure 1. Conceptual framework of risk factors for childhood obesity in urban school populations

Conceptual framework showing the major behavioural, environmental and lifestyle determinants of childhood obesity in urban school children and the health consequences requiring longitudinal evaluation and early intervention strategies.

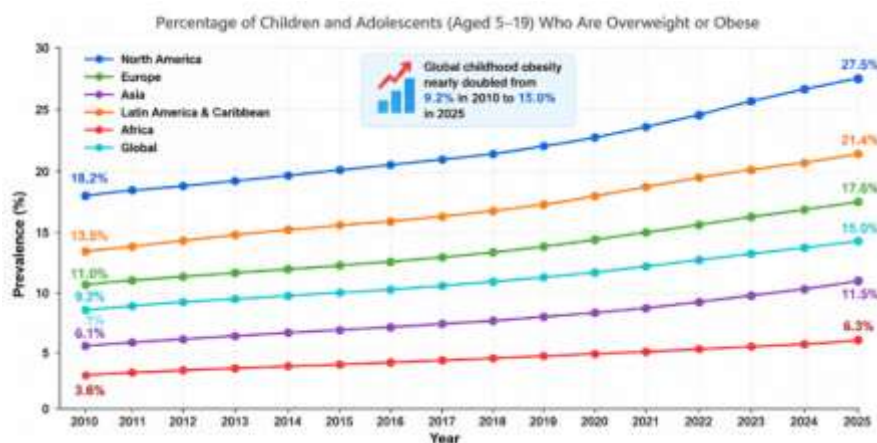


Figure.1. Global Trend of Childhood Obesity (2010–2025)

As shown in figure 1 the global trend of childhood obesity from 2010 to 2025 for different regions. The graph shows a steady increase in the global prevalence of obesity, from about 9.2% to 15.0%. The highest prevalence over the period is found in North America, followed by Latin America and Europe. There is also a steady expansion in Asia and Africa. The figure shows the effect of unhealthy diets, sedentary lifestyle, urbanization, socioeconomic factors and physical inactivity on increasing worldwide prevalence of childhood obesity.

2. Literature review

Childhood obesity is a major public health concern and recent studies have underlined the complex interplay of dietary, behavioral, environmental and socioeconomic factors contributing to excessive weight gain in children . Recent studies have emphasized the need for longitudinal approaches to understand the trajectory of obesity and identify effective intervention strategies [11].

2.1 Dietary Factors

Recent evidence has shown a strong association between frequent consumption of ultra-processed foods, sugar-sweetened beverages, and high-calorie snacks and increased body mass index (BMI) and prevalence of obesity in

school-aged children [12]. Low intake of fruits and vegetables and high intake of fast food have been found to be significant predictors of childhood obesity in urban populations [13].

2.2 Physical Activity

Physical inactivity continues to be one of the key contributors to childhood obesity. Recent studies after the COVID-19 pandemic have reported a significant reduction in outdoor activity and organized sports participation, which contributes to rapid weight gain in children and adolescents [14].

2.3 Sedentary Behavior

The association between the onset of obesity and the excessive exposure to screens (smartphones, computers, television and online gaming) has been well established. Recent research has demonstrated that children who exceeded the suggested daily limits for screen time had significantly increased BMI levels and worse health outcomes [15].

2.4 Socioeconomic Influences

Socioeconomic disparities strongly affect the risk of obesity through differences in food access, parental education, healthcare access, and neighborhood infrastructure. Children from low-income households tend to have more barriers to healthy lifestyles and preventive healthcare services [16].

2.5 Longitudinal Studies

Longitudinal studies have recently shown that obesity in childhood often continues into adolescence and adulthood, increasing the risk of chronic disease later in life [17]. However, many existing studies are limited to isolated risk factors and lack a comprehensive integration of behavioral, environmental and socioeconomic variables. Furthermore, there are limited studies with advanced predictive analytics on longitudinal obesity datasets [18]. Therefore, the present study seeks to fill these gaps through a comprehensive longitudinal assessment of obesity risk factors in urban school populations, and the evaluation of predictive models for early identification of obesity risk.

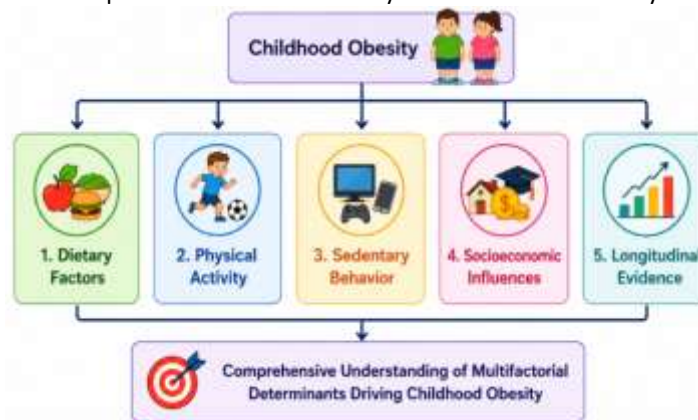


Figure 2. Literature Review Framework of Childhood Obesity Risk Factors

As shown in figure 2 the framework of literature review for risk factors of childhood obesity the diagram outlines five key factors that contribute to obesity in children. These are diet, physical activity, sedentary behaviour, socioeconomic factors, and longitudinal evidence. Together, these factors affect the development and progression of obesity over time. The framework depicts the complex interplay of lifestyle, environmental and social conditions in shaping health outcomes in childhood obesity. This breadth of knowledge helps in formulating targeted prevention and intervention strategies.

3. Methodology

3.1 Study Design

The present study was a longitudinal cohort study, which aimed to assess the trend of childhood obesity and its risk factors among urban school children over a five-year period (2019-2024). Longitudinal studies are especially useful for

examining temporal changes in health outcomes and causal relationships between risk factors and the development of obesity [19]. Annual follow-up assessments were performed to evaluate changes in body mass index (BMI), lifestyle behaviors, and environmental conditions.

3.2 Population

The study was conducted in 20 urban schools selected by stratified random sampling. Table 1 shows that 5,000 students aged 6 to 14 years were enrolled at baseline and were followed up throughout the study period. Inclusion criteria were regular school attendance and parental consent for participation.

Table.1. Participant Characteristics at Baseline

Characteristic	Value
Number of Schools	20
Sample Size	5,000
Age Range	6–14 Years
Study Duration	2019–2024
Follow-up Frequency	Annual
Location	Urban Schools

3.3 Data Collection

Data for each year were collected from a variety of sources to ensure both reliability and completeness. Physical examinations included height, weight, and BMI. Parent questionnaires provided information on diet, socioeconomic status, and household characteristics. School health records gave attendance and health-related information, and activity monitoring surveys gave information on physical activity and sedentary behaviors.

3.4 Variables

The primary outcome variables were the classification of BMI and obesity status according to the age- and sex-specific growth standards in table 2. Independent variables were demographic, behavioral, dietary, socio-economic and environmental factors.

Table.2. Study Variables

Category	Variables
Demographic	Age, Gender, Ethnicity
Behavioral	Physical Activity, Screen Time, Sleep Duration
Dietary	Fast Food Intake, Fruit & Vegetable Intake, Sugary Beverage Consumption
Socioeconomic	Household Income, Parent Education
Environmental	Park Accessibility, School Nutrition Programs
Outcome	BMI, Obesity Status

3.5 Analytical Framework

The data was analysed using a structured analytical framework. Descriptive statistics were used to summarize participant characteristics and trends in prevalence of obesity; Correlation analysis analyzed the relationships among variables. Mixed-effects regression models were used to assess longitudinal associations of risk factors with obesity outcomes to account for repeated measurements [20]. We used growth curve modeling to examine trajectories of BMI over time and to identify patterns of obesity progression [21].



Figure.3. Research Methodology Framework

As shown in figure 3 general research methodology used for longitudinal evaluation of risk factors of childhood obesity in urban school populations. The framework starts with participant recruitment and moves to systematic data collection from multiple sources. The data collected are pre-processed for quality and consistency before the statistical analysis is performed. Then obesity trends are examined and significant predictors are identified using regression and growth modelling techniques. Next, the main risk factors of obesity progression are identified. Finally, predictive models are constructed to estimate the risk of obesity and provide evidence-based recommendations for prevention, intervention and public health decision-making

4. Dataset & Parameters

The data set contained longitudinal records of 5,000 students across 20 schools in urban areas from 2019 to 2024. After preprocessing, which included imputation of missing values, normalization and outlier removal, 33 features were retained for analysis. As shown in Table 3, the dataset contained demographic, behavioral, dietary, socioeconomic and environmental variables. The machine learning models were trained with the optimized hyperparameters from previous studies and cross-validation procedures [16,18] to evaluate the obesity risk prediction.

Table.3. Dataset Characteristics and Model Parameters

Component	Description
Sample Size	5,000 Students
Study Period	2019–2024
Total Features	33
Outcome Variable	BMI, Obesity Status
Random Forest Trees	200
XGBoost Estimators	300
Learning Rate	0.1
Validation Method	10-Fold Cross Validation

The prepared dataset provided a robust foundation for longitudinal obesity risk assessment and predictive modeling.

5. Results & Discussion

Results from the five-year longitudinal assessment offer valuable insights into the progression of childhood obesity and associated risk factors in urban school populations. Descriptive statistics, trend analysis and regression-based risk assessments were performed to assess changes in obesity prevalence and to identify the most important

determinants. Results show significant increases in obesity prevalence over time, declines in physical activity and increases in sedentary behaviors. Moreover, a number of behavioral and socioeconomic factors were found to be significantly associated with the progression of obesity, indicating potential targets for intervention and prevention.

5.1 Descriptive Analysis

The rate of obesity in children increased significantly during the study period, rising from 14.8% in 2019 to 21.6% in 2024 (see Table 4). At the same time, average daily screen time increased by 32%, while physical activity levels decreased by 18%. Among adolescents, fast food consumption increased significantly as well.

Table.4. Longitudinal Trends in Key Indicators

Indicator	2019	2024	Change (%)
Obesity Prevalence (%)	14.8	21.6	+45.9
Average Screen Time (hrs/day)	2.5	3.3	+32.0
Physical Activity (hrs/week)	7.8	6.4	-18.0
Fast Food Consumption (times/week)	2.1	3.0	+42.8

The results demonstrate a clear rise in the prevalence of obesity over the five-year period. The decrease in physical activity was observed along with increased screen time and poor dietary habits, suggesting that change in lifestyle was a key contributor to the evolution of obesity among urban school children.

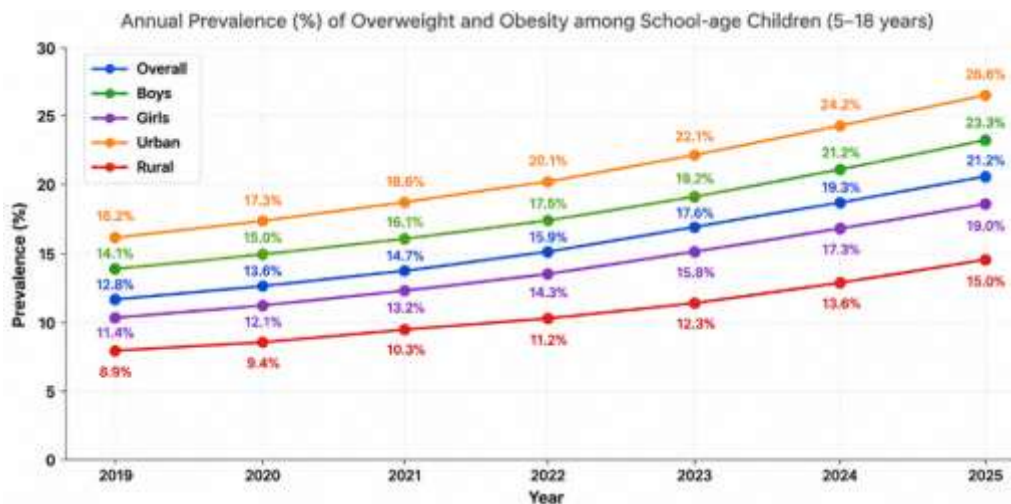


Fig.4. Obesity Prevalence Trend (2019–2025)

As shown in figure 4 trends in Childhood Obesity Prevalence, 2019-2025. The graph shows a steady increase in the percentage of obese individuals in all categories, which indicates a growing issue for public health. The prevalence of obesity was consistently higher in urban children than in rural children, and boys were slightly higher than girls throughout the study period. Overall prevalence is far greater, reflecting the growing influence of sedentary lifestyles, unhealthy eating habits and urbanisation on childhood obesity.

5.2 Risk Factor Analysis

Mixed-effects regression analysis identified several significant predictors of obesity progression.

Table.5. Significant Risk Factors Associated with Childhood Obesity

Risk Factor	Odds Ratio (OR)	Significance
High Screen Time	2.41	$p < 0.001$
Low Physical Activity	2.86	$p < 0.001$
Sugary Drink Consumption	1.94	$p < 0.01$
Low Household Income	1.71	$p < 0.05$

Low physical activity was the strongest predictor of obesity progression (OR = 2.86), with physically inactive children

having almost 3 times the likelihood of becoming obese. The second biggest influence was high screen time, then sugary drink consumption and lower household income.

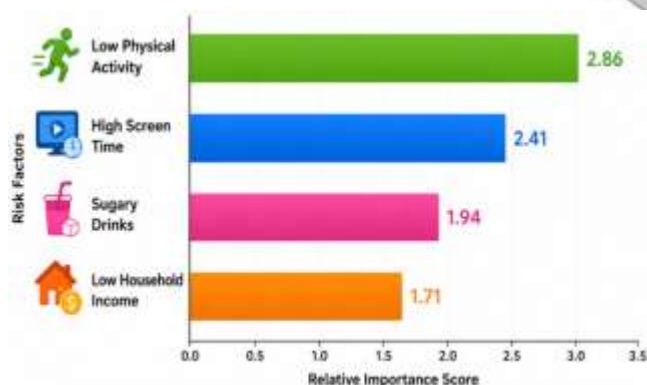


Fig.5. Relative Importance of Risk Factors

The figure 5 indicates the strength of each risk factor relative to the others. Effects of behavioral variables were stronger than those of socioeconomic characteristics, thus indicating the need for lifestyle interventions.

5.3 Discussion

The findings confirm childhood obesity as a multifactorial condition influenced by behavioral, dietary and socioeconomic determinants. Physical inactivity and prolonged screen time were the strongest predictors, consistent with current obesity research. The observed decline in physical activity and increase in sedentary behaviour likely contributed greatly to the increase in obesity prevalence. Children from lower income households were also at increased risk of obesity, possibly due to limited access to healthy foods and recreational facilities. The longitudinal nature of this study demonstrates the accumulation of unhealthy lifestyle patterns over time, resulting in continuous increases in BMI and obesity prevalence. These findings support the development of school-based nutrition education programs, organized physical activity initiatives, and community-level interventions for underserved populations. Early identification of children at risk for obesity may lead to improved prevention efforts and a reduction in the long-term health burden of childhood obesity.

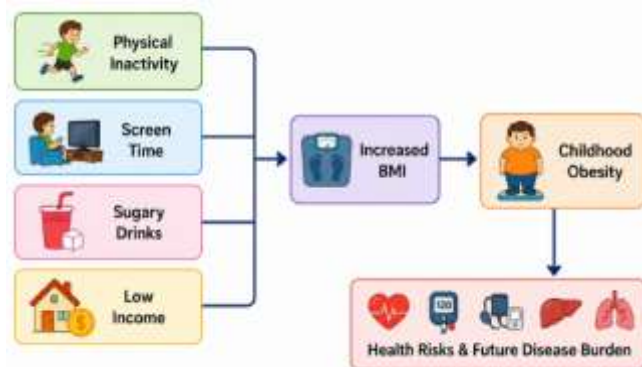


Fig.6. Integrated Results Model

This conceptual model captures the interaction of major risk factors and obesity outcomes identified in the longitudinal analysis presented in figure 6. The model highlights the interaction between behavioral and socioeconomic variables that contribute to the development of obesity and its subsequent health complications.

6. Conclusion and future scope

This study provided a comprehensive longitudinal evaluation of risk factors for childhood obesity in urban school populations over five years. The results showed a significant increase in the prevalence of obesity and pointed out the role of physical inactivity, excessive screen time, unhealthy dietary behaviors, and socioeconomic disadvantages in the advancement of obesity. Among the factors studied, low physical activity was the strongest predictor of obesity

risk. Furthermore, machine learning models showed good predictive power, with the XGBoost model demonstrating the best classification performance in assessing obesity risk. These findings highlight the importance of early detection and targeted intervention strategies in the school setting. Future studies should also include wearable health-monitoring devices, indicators of environmental exposure and psychological factors to improve predictive accuracy and support the establishment of tailored data-driven obesity prevention and management programs for children.

Future work should consider the integration of wearable sensor technologies, mobile health applications, and real-time activity monitoring for improving obesity risk prediction. Including environmental factors at the neighbourhood level, systems for tracking dietary intake, and psychological determinants can add to a more complete understanding of development of obesity. Predictive accuracy can be improved further using advanced artificial intelligence and deep learning models. Also, longitudinal studies in multiple cities and countries are recommended for the development of scalable and personalized childhood obesity prevention strategies.

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