

## GLOBAL BURDEN OF OBESITY IN CHILDREN UNDER 5 YEARS OF AGE: TRENDS, REGIONAL DISPARITIES, AND INSIGHTS FROM SOUTH ASIA TO DEVELOPED COUNTRIES (2000–2020)

Ayesha Noreen<sup>1</sup>, Ghulam Murtaza<sup>\*2</sup>, Samavia Riaz<sup>3</sup>, Razia Sultana<sup>4</sup>, Iqra Amin<sup>5</sup>, Eman Ejaz<sup>6</sup>, Turki Abualait<sup>7</sup>, Shahid Bashir<sup>8</sup>

<sup>1,\*2,3,4,5,6</sup>Department of Zoology, University of Gujrat, Gujrat, Punjab 50700, Pakistan.

<sup>7</sup>College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, P O Box 32241 Dammam, Saudi Arabia

<sup>8</sup>Neuroscience Center, King Fahad Specialist Hospital, Dammam, 31444, Saudi Arabia.

<sup>1</sup>ayeshanoreen062@gmail.com, <sup>2</sup>gmurtazay@yahoo.com, <sup>3</sup>samriaz5009@gmail.com, <sup>4</sup>raziam25@yahoo.com, <sup>5</sup>iqraaminawan@gmail.com, <sup>6</sup>emanejaz100@gmail.com, <sup>7</sup>tsabualait@iau.edu.sa, <sup>8</sup>shahidbpk13@gmail.com

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Corresponding Author: \*

Ghulam Murtaza

### Abstract

Childhood obesity, particularly among children under five years of age, has emerged as a significant global health issue, with a notable increase in prevalence across various regions of the world from 2000 to 2020. This review examines the epidemiological patterns, etiology, and clinical impact of childhood obesity between 2000 and 2020, with particular attention paid to South Asian countries in relation to both developing and developed countries. The analysis highlights an increasing obesity rate worldwide, attributed to nutritional changes, less active lifestyles, urbanization, and socio-environmental modifications. Etiological factors such as lack of physical activity, an unbalanced diet, genetic factors, hormonal disorders, and exposure to the environment, as well as the contribution of perinatal and behavioral factors, are reviewed in detail. The review also describes implications of early-onset obesity, including the development of cardiovascular diseases, metabolic syndrome, non-alcoholic fatty liver disease, and comorbidities in relation to other psychological disorders. Special consideration is given to South Asia, where the phenomenon of an underweight population coexists with the problem of incipient obesity in the context of highly complicated socio-economic and cultural processes. Prevention and management strategies exist in areas like infant feeding practices, physical activity, sleep hygiene, community education, and policy interventions. Moreover, evidence-based recommendations that underline the value of early intervention, multi-sectoral integrated strategies, and enhanced surveillance systems are discussed. This evidence has practical implications that public health professionals and policymakers can use to help reduce the extent of childhood obesity in the future and create a healthier outlook in

*various parts of the world.*

## INTRODUCTION

The recognition of obesity as a disease was theoretically established by the World Health Organization (WHO) in 1948. According to the WHO, obesity is an excessive or abnormal deposition of body fat that is harmful to one's health. Obesity is characterized by having a body mass index (BMI) for age at the 95th percentile. It increases the risk of high cholesterol levels that are associated with heart diseases, diabetes, breathing problems, depression, and anxiety. Socioeconomic factors such as low socioeconomic status, limited parental education, poor diet, inadequate sleep, and parental obesity can contribute to obesity in children. Additionally, family history, lifestyle, and psychological factors also play an important role in the prevalence of obesity<sup>[1]</sup>. The problem of childhood obesity, especially among children younger than five years old, has become a pressing worldwide health issue. It was viewed as an issue of high-income countries only. However, low- and middle-income countries have started to deal with it with a significant increase over the past twenty years. According to the WHO, there are more than 39 million children below the age of five years in 2025 who are overweight or are undergoing a stage of obesity<sup>[2]</sup>. This overwhelming change emphasizes the necessity to tackle childhood obesity as an individual condition in addition to a predisposing factor to future health related-problems.

Early childhood obesity is highly likely to develop non-communicable diseases, including type 2 diabetes, hypertension, dyslipidemia, and cardiovascular diseases in later stages of life. Moreover, it is linked with psychosocial problems like low self-esteem and depression<sup>[3]</sup>. Obese children have a higher tendency to become obese as adults, perpetuating the cycle of ill health and higher cost of treatment<sup>[4]</sup>. Childhood obesity etiology is multifactorial, and it is multi-compositional, including interactions of biological (genetic nature) and behavioral factors,

socioeconomic status, urbanization, and environmental exposures. Although the overconsumption of calories and lack of physical activity among the population are frequently listed as the proximate causes, the more comprehensive structural determinants, including systemic changes in foods available in the market, marketing of energy-rich processed foods, and environmental constraints, are critical factors<sup>[5]</sup>. Notably, these determinants are quite different in different regions of the world. As an example, in highly developed countries, like the United States (US) and Qatar, there has been a steady rise in the prevalence of obesity among children under 5 years of age, which currently reaches 13-14% in certain locations<sup>[6]</sup>. Whereas in South Asia, the prevalence is currently lower, though it bears the signs of a steady increase by the same factors as in developed countries, like urbanization and changing diets<sup>[7]</sup>.

There is also increasing concern about the double burden of malnutrition, where one finds undernutrition and obesity existing together in the same population, the same household, or even in the same individual. This is a paradox that is most evident in South Asian countries, where the economy has been developing at a fast rate in such a way that food availability, consumption, and lifestyle habits have been changing at a meteoric rate<sup>[8]</sup>. This review seeks to critically discuss the global burden of obesity in children below the age of five years between 2000 and 2020. It also examines temporal and regional trends, especially focusing on the differences that exist between the countries of South Asia and the developed ones. Secondly, the review examines the basic etiological reasons that lead to obesity, the prophylaxis and treatment strategies that are based on evidence. The integration of epidemiological data and the use of contextual analysis aim to link study findings to the practical guidelines that can be used by professionals in the domain of public health, policy-makers, and researchers who are

concerned with the issues of early childhood obesity reversal.

## **Methodology**

This review article provides a narrative overview of the global and regional burden of child obesity in children less than 5 years of age from 2000 to 2020. The combination of authoritative databases and published literature was used to find relevant data. Among the sources used, key ones were the global health institutions, including the WHO, United Nations Children's Fund (UNICEF), and World Bank, as well as scholarly publications that were indexed by PubMed, Scopus, and Google Scholar. Search terms included combinations of "childhood obesity," "children under 5," "obesity prevalence," "South Asia," "developed countries," and "global trends." The search was limited to English-language publications from the year 2000 onward.

The criteria used in selection included articles with studies or reports of children below the age of 5 years, articles including regional or national statistics on prevalence, and articles about obesity as far as etiology, management, or prevention is concerned. The studies that involved older children and cases where studies examined adult people or where the regional focus was not applicable were discarded. The prevalence rates were taken as quantitative data extracted from epidemiological surveys and global health databases. A descriptive comparative analysis of regional differences, temporal trends, and thematic synthesis of causes, interventions, and outcomes of childhood obesity was done. There was a focus on discovering trends and differences between countries of South Asia, developing and developed countries.

## **Epidemiology**

Obesity is a preventable pathological condition that is determined by the unreasonable increase in the adipose tissue of the body. Its main cause in children is the existing unbalanced relationship between intake and expenditure of energy in combination with limited physical

activity, poor dietary preferences, and socio-environmental aspects. Some common causes include unbalanced consumption of high-calorie foods, poor physical activity, sedentary lifestyles, poor sleeping habits, and restricted provision of nourishing foods. Marked problems connected with obesity in children are the high chances of contracting cardiovascular diseases, pre-diabetes, musculoskeletal diseases, and psychological conditions <sup>[9]</sup>. Childhood obesity has become a pandemic in the whole world. The WHO estimates that in 2020, 39 million children below the age of five years were either overweight or obese. Physical health, as well as the emotional and social well-being of children, is impacted by obesity. Children who are obese have an increased possibility of being bullied and socially ostracized, as well as poor academic outcomes. Moreover, childhood obesity is a robust predictor of obesity in adulthood, which is characterized by enhanced morbidity and mortality rates related to non-communicable diseases, e.g. obesity-related diabetes, hypertension, and some cancer-related mortalities <sup>[10]</sup>.

Shifting global eating habits, more screen time, sedentary lifestyle, fast urbanization, and industrialization have contributed greatly to the growing obesity levels in developed and developing countries. Today, obesity is estimated as one of the highest priority health problems of the 21st century and likely affects the health systems of nearly every nation as well as the world economy <sup>[11]</sup>. The global prevalence of childhood obesity was estimated to be about 170 million children in 2008. That number was much larger by 2020. The countries having the largest obesity rates are Qatar, with around 34-35% of the population being obese, and the US, with 32-34% of Americans fitting the obese category. In terms of the overall burden, obesity is liable for over 36 million Disability-Adjusted Life Years (DALYs) worldwide, highlighting its extensive impact on both the individual and population-level health outcomes <sup>[12]</sup>. Historically, obesity was regarded as a concern predominantly in affluent societies. However, due to quick global changes

in the diet, lifestyle, and urban infrastructure, developing countries are now likewise affected. South Asian countries, for instance, are observing a shift from undernutrition to the dual burden that comprises rising rates of obesity, mainly in the urban areas. In Pakistan, the childhood obesity rate declined from 5.0% in 2008 to 3.4% in 2020, while in India it dropped from 3.3% to 1.9% during the same period <sup>[13]</sup>. These national trends, though, hide wide disparities among urban and rural populations.

In the meantime, obesity continues to increase in developed countries. According to the WHO European Childhood Obesity Surveillance Initiative (COSI), the prevalence of childhood obesity in numerous EU nations rose significantly between 2008 and 2010, with some countries recording that almost one-third of the children were affected <sup>[14]</sup>. Australia exhibited a similar pattern, with the prevalence of obesity among children increasing from 8.2% in 2000 to 18.5% in 2020 <sup>[15]</sup>. Interpreting the prevalence of childhood obesity and tracking its occurrence are important components in the effective response to obesity in society. Surveillance allows policymakers to distribute resources, assess the effectiveness of the interventions as well, and determine the high-risk groups. The overall evaluation of trends of childhood obesity since 2000 and onwards can be used to develop evidence-based, region and country-specific strategies. The given epidemiological review proves that action taken on a worldwide scale is highly crucial. Multi-sectoral methods, such as policy reform, public health education, environmental reorganization, and clinics are needed to curb childhood obesity. Providing precise and timely information, such research helps to make the right decisions and long-term plans to have healthier new generations.

## **Etiology**

Childhood obesity is a complex disorder that has a complex set of determinants, including lifestyle, socio-environmental factors, genetic factors, endocrine factors, psychosocial factors, and stress.

To come up with effective public health policies and interventions aimed at mitigating these drivers, a thorough understanding of the drivers is crucial. Below is further elaboration of the biological and behavioral features of a child, environmental factors, and socio-economic processes leading to childhood obesity, especially where developed and South Asian countries can be compared.

## **Physical inactivity and energy imbalance**

The major cause of obesity is a disparity between energy intake and expenditure. Children from various high-income nations have sedentary lifestyles. Overconsumption of media entertainment and the absence of outdoor playing fields have contributed to a lack of physical activity <sup>[16]</sup>. Also, children are subjected to the advertisement of fast foods and the intake of energy-dense foods, which also facilitates an increase in weight. In infants and children aged below 10 years, sedentary behavior and adiposity had a strong correlation observed in studies <sup>[17]</sup>. Alternatively, rural South Asia children actively participate in play and walking outside in greater amounts than their urban counterparts, but these walking and play activities are on the decrease with urbanization <sup>[18]</sup>.

## **Nutritional transitions and dietary behaviors**

The daily diet has shifted from home-cooked nutrient rich to highly processed, convenient, appetizing foods that are high in sugar, salt, and unhealthy oils. Various developed countries experience this transition, which has also recently infiltrated South Asia. It is reported in the Global Nutrition Report (2020) that the accessibility of processed food in low- and middle-income countries has fueled the growth of childhood obesity levels. Urban areas are synonymous with snacking habits and drinking sweetened drinks. In some high-income countries, the proportion of ultra-processed products in caloric food increased to more than 50%. Such dietary patterns are deficient in nutrients such as dietary fiber and

other vital nutrients which have resulted in early adiposity.

### **Environmental and socioeconomic determinants**

Poor walkability, the absence of green spaces, and food deserts create obesogenic environments that restrict physical activity and access to healthy food. Socioeconomically disadvantaged children are the most affected in high-income countries because of generally low accessibility to health-promoting environments<sup>[19]</sup>. In South Asia, the distribution of traditional food environments was not favorable to obesity, but an increasing level of economic development has resulted in the introduction of processed food products and reduced levels of physical activity, especially in urban middle-class residents.

### **Endocrine and hormonal deregulation**

Body weight is regulated by biological mechanisms in the body, entailing a complex network of hormones and neuronal feedback. The balance of energy is maintained by the hypothalamus with the help of these two hormones: ghrelin (which increases appetite) and leptin (which promotes feelings of satiety). Leptin insensitivity may occur among obese children, which leads to the failure to signal satiety<sup>[20]</sup>. Moreover, the change in insulin sensitivity, cortisol, and adipokines leaves its mark by forming a metabolic imbalance and fat accumulation. These hormonal imbalances may be observed early in life and may be worsened by poor diet and sleeping habits. Another interesting factor that leads to the increase in fat mass, especially central adiposity and lean body mass loss, is growth hormone (GH) deficiency. The patients who are GH- deficient have distorted lipid metabolism, and benefits have been observed when they receive GH therapy<sup>[21]</sup>. Less prevalent causes of weight gain include Cushing syndrome and hypothyroidism, either of which has the effect of slowing metabolism.

### **Genetic and syndromic obesity**

While environmental and behavioral factors are the main contributors to global obesity prevalence, genetic factors account for individual susceptibility. Monogenic obesity develops as a result of a mutation in genes, such as leptin and melanocortin-4 receptor (MC4R), which can be found in 3-5% of children with early-onset obesity<sup>[22]</sup>. Syndromic obesity, which comprises diseases such as Prader-Willi syndrome and Bardet-Biedl syndrome, is characterized by developmental delay, intellectual disability, and hyperphagia. Besides rare genetic syndromes, polygenic barriers influence the control of appetite, distribution of fat, and the basal metabolic rate. These genetic inclinations also combine with environmental indicators, implying that the measures required must be customized and culturally organized.

### **Microbiome and metabolic interactions**

There are also new facts that point to the contribution of the gut microbiota in the pathophysiology of obesity. In the human gut, millions of bacteria colonize the gastrointestinal system that affect digestion, absorption of nutrients, inflammation and regulation of energy. A change in microbial diversity, which is referred to as dysbiosis, is linked with the higher generation of short-chain fatty acids that boost the fat storage process and insulin unresponsiveness<sup>[23]</sup>. Mode of delivery (C-section) and early exposure to antibiotics also influence microbial composition as well as feeding of the infants. The role of the microbiome in obesity has been examined very rarely in countries in South Asia, and this shows that further studies are required. Future obesity prevention may be promising to have nutritional interventions that apply towards the restoration of healthy microbiota.

### **Sleep deprivation and circadian disruption**

The quality and time of sleeping directly influence the hormonal regulation of hunger and energy expenditure. Ghrelin is raised, and leptin

is lowered by sleep deprivation, which raises the level of desire and the amount of calories consumed. Also, poor sleep is associated with tiredness, which will result in less activity. It was discovered that the reduced sleep time of children was associated with elevated BMI scores in various populations<sup>[24]</sup>. Digital technology that has increasingly dominated both developed and developing environments has extended the time spent on screens at the cost of sleep. These trends are increasing influencing the population of South Asian urban households, especially children of school-going age who experience academic stress and have unstable sleep schedules.

### **Medical conditions and medications**

Obesity can also be secondary to medical diseases or side effects of medication. Children with chronic diseases like asthma, epilepsy, or endocrine diseases may receive drugs encouraging weight gain. Increased appetite and insulin resistance, in particular, are connected to corticosteroids and antipsychotics<sup>[25]</sup>. Insulinoma is also rare, but it leads to hypoglycemia with a resultant overeating. With the prescription of long-term medication to children, close medical supervision, dosage adjustments, and regular weight and BMI monitoring are necessary. Dietary counseling followed by incorporation into the therapeutic strategies can reduce weight gain caused by pharmacology.

### **Psychosocial and behavioral influences**

Eating behavior in children is deeply connected with aspects of emotional well-being. Emotional or binge eating is one of the symptoms of stress, anxiety, and low self-esteem. Those kids who are bullied by other children, or are not accepted by peers because of being overweight, will resort to unhealthy eating habits. Isolation also lowers physical activity and aggravates obesity. These are the psychosocial patterns prevalent in the high-income countries as well as the emerging economies. The stigmatization of obesity and mental conditions may postpone the diagnosis

and intervention in South Asian communities<sup>[26]</sup>. These dimensions of behavior require a multi-disciplinary approach by including pediatricians, nutritionists, and mental health care professionals.

### **Obesity-related comorbidities**

Several comorbidities are involved in early childhood obesity. Metabolic syndrome is a formerly adult metabolic syndrome that has been found more often in obese children. The syndrome comprises abdominal obesity, insulin resistance, dyslipidemia, and hypertension<sup>[27]</sup>. Another effect is hepatic steatosis or non-alcoholic fatty liver disease (NAFLD), which disturbs the liver function and insulin sensitivity. Additional complications are orthopedic complications (e.g., Blount disease), worsening of asthma, and early signs of heart disease. It is crucial to diagnose these conditions in the early stages and integrate regular screening with infant medications as a way of reducing long-term sequelae.

Childhood obesity is multi-factorial and intertwined. Although the genetic, hormonal, and medical factors also contribute, lifestyle and environmental factors are still predominantly above, and thus, they are adjustable. Regional disparities in these determinants, shaped by urbanization, economic development, healthcare access, and cultural beliefs, show a requirement for nuanced, evidence-based strategies. The remaining root causes should be addressed by implementing combined multi-disciplinary and multi-cultural competent strategies as the only way of enabling the mitigation of the current trends and lifelong health promotion.

### **Data Analysis of Global and Regional Variations Prevalence of obesity in different regions of the world from 2000 to 2020**

According to data collected from 2000 to 2020, Australia faced the highest burden of obesity (13.2%). In other regions such as Europe, America (North and South), and Africa, the prevalence rates of obesity were 9.1%, 7.6%, and

5.6%, respectively. However, in Asia and Southern Asia, the prevalence rates (4.9% and 3.0%, respectively) were low compared to other regions [Figure 1]. In Australia, the prevalence rate was 8.2 in 2000, which consistently increased to 18.5% in 2020. Likewise, America and Asia also exhibited a consistent increase in the tendency towards obesity during the period of analysis. In Europe, obesity increased and decreased consistently from 2000 to 2010 and 2011-2020, respectively. In Africa, obesity prevalence remained fluctuating between 6.5% and 5%. In South Asian countries, obesity prevalence consistently decreased from 2001 to 2020 [Figure 2].

#### **Prevalence of obesity in South Asian countries from 2000 to 2020**

The statistics indicate that the prevalence of obesity in South Asian countries is not at an alarming level. Among the South Asian countries, obesity was not at an alarming stage. Comparative analysis showed that the prevalence rate was the highest in Bhutan (5.5%), followed by the Maldives (5.4%) and Pakistan (4.6%). Whereas other countries, including India, Bangladesh, Nepal, and Sri Lanka, faced a very low burden of obesity with a prevalence rate of less than 3% [Figure 3]. South Asian countries, overall, exhibited a fluctuating trend of obesity prevalence. In Pakistan, the prevalence rate was 4.8% in 2000, increased until 2007 (5.1%), then decreased to 3.4%. In the same way, in Bhutan, this rate increased from 4.3% to 6.1% (2000 to 2011), then decreased to 5.2% in 2020. In other countries, the situation is not as stressful, as minor changes occur in the prevalence rate of obesity (Maldives: 4.4%-4.6%, Nepal: 0.9%-1.8%, Bangladesh: 0.7%-2.1%, Sri Lanka: 1%-1.3%). Surprisingly, the prevalence rate in India decreased from 3.3% to 1.9% [Figure 4].

#### **Prevalence of obesity in developed countries from 2000 to 2020**

The developed countries, including Canada, the USA, Portugal, and Qatar, faced a high burden

of obesity in underage children. The Prevalence of obesity in these countries is high and has increased over 20 years. Qatar faced the highest prevalence (13.9%), followed by Canada (11.8%), Portugal (8.5%) and Poland (6.7%) in children of less than five years of age [Figure 5]. Moreover, these countries showed a tendency to increase in obesity prevalence. For instance, initially, in 2000, in Qatar, Canada, Portugal, and Poland, the prevalence rates were 9.9%, 8.8%, 5.6% to 8.5%, and 4.5%, respectively, which remained continuously increasing [Figure 6].

#### **Reasons for regional differences in childhood obesity**

The disparity in the prevalence of childhood obesity between South Asian countries and developed nations is predominantly driven by dissimilarities in dietary behaviors, lifestyle patterns, socio-economic conditions, as well as healthcare infrastructure. Such aspects are not only influenced in their risk environment towards obesity among children but also towards its rate and character of incidence across the regions.

The tendency towards growing rates of childhood obesity in high-income countries is related to their intake of ultra-processed food sources, which are characterized by a high content of refined sugar, saturated fats, and additives<sup>[28]</sup>. Accessibility of fast foods, portion size, and physical marketing to children promote overeating calories<sup>[29]</sup>. According to the Global Burden of Disease Study, in the US, childhood obesity rates among children under five rose from 8.6% in 2000 to over 10% by 2020<sup>[30]</sup>. Such eating habits are further exacerbated by lifestyles such as being sedentary (spending most of their time in front of a screen and exercising less) that are becoming common practices in progressive urban and technological communities<sup>[31]</sup>.

On the contrary to this the prevalence of obesity is lower in South Asian countries at present. As an illustration, the UNICEF (2021) statistics show that in the majority of South Asian countries, such as India, Bangladesh, and Nepal,

the prevalence of child obesity under the age of five years is less than 5% <sup>[32]</sup>. To a large extent, this variance can be attributed to the traditional eating habits that emphasize home-cooking with reduced fat content, increased physical activity since manual form of transportation is used, and reduced usage of processed foods <sup>[33]</sup>.

This is gradually changing, however. South Asia is experiencing a transition in diet due to factors such as urbanization, rising incomes that lead to higher disposable incomes, and the spread of western dietary practices <sup>[34]</sup>. Exposure to processed food, high-sugar drinks, and a sedentary lifestyle is also growing among urban children, increasing their risk of obesity. A study by Harding et al. (2018) reported that in urban Pakistan, the prevalence of obesity in children under five rose from 4.8% to 5.1% in the time span from 2000 to 2007 before slightly decreasing to 3.4% in 2020, demonstrating variations rather than eradication <sup>[35]</sup>.

Also, inequality in the right to healthcare and lack of awareness of obesity can lead to underreporting and late diagnosis in South Asia. Poor health literacy and lack of routine screenings also imply that children with obesity might not be diagnosed at the initial stages of development <sup>[36]</sup>. Moreover, early intervention can be hindered by cultural perceptions in which people see weight gain as a sign of being wealthy <sup>[37]</sup>.

Biological and environmental determinants, like endocrine-disrupting chemicals and variations in the gut microbiota, also contribute to the regional variances in obesity susceptibility <sup>[38]</sup>. These determinants could increase the risk of obesity in particular environments, but they are poorly studied in their interaction with socio-environmental factors among South Asian people. In short, although industrialization and overindulgent lifestyles in the developed countries are leading to an epidemic, the South Asian nations are at a transition period where they have a dual burden of nutrition and emerging obesity. To solve these regional disparities, it is important to use culturally,

economically, and environmentally relevant public health interventions.

### **Prevention and management strategies for childhood obesity**

The problem of obesity in children is a multifactorial condition that needs a multidimensional approach to prevent and manage it successfully. To deal with children under 5 years of age who have developed obesity, a powerful combination of early intervention, population education, healthcare reform, and national legislation is necessary to stop the rise of this problem. The given strategies are organized in fundamental fields and backed by international recommendations and case studies.

### **Infant feeding practices**

Early-life nutrition has a significant role in future well-being. The World Health Organization (WHO) recommends exclusive breastfeeding for six months or less, and it has also been linked with a lower risk of future childhood obesity <sup>[39]</sup>. Bottle-fed infants tend to become overfed, which puts them at risk of gaining excess weight <sup>[40]</sup>. Other protective measures found against early-onset obesity are the late introduction of complementary foods (ideally after six months). Breastfeeding needs to be advocated, and lactation support should be given to new mothers; this should be done through public health campaigns, primarily in urban areas where the use of formulas is more popular.

### **Physical activity**

Physical activity helps to keep a healthy weight and metabolic profile of children. It is advised that children aged 3 to 5 years should engage in active play during the day, whilst those aged 2 to 6 may not exceed an hour of screen time daily, with children younger than two not being exposed to screen time at all <sup>[41]</sup>. Physical activity interventions conducted in preschools have successfully shown positive results. In another example, a planned, curriculum-based intervention brought about a drop in obesity

levels in the US within a period of two years because it included daily physical activities and minimized sedentary behavior <sup>[42]</sup>. Community-based interventions like safe play areas, walking school buses, and child-focused recreational programs have also been found to work well in enhancing levels of physical activity <sup>[43]</sup>. These must be scaled up and should be according to the needs of both people living in urban and rural areas.

### **Healthy dietary patterns**

Obesity is preventable, and a balanced, nutrient-dense diet is fundamental for its prevention. Children should have a diet rich in fruits, vegetables, whole grains, and lean proteins, in addition to reducing sugary drink consumption, highly processed snacks, and fast foods <sup>[44]</sup>. It needs parents as interventional agents who influence dietary habits. The household environment can be supportive through healthy eating habits of parents, a regular meal schedule, and restriction of high-calorie convenience foods. The international experiences reflecting the availability of fruits, vegetables, and low-fat dairy in school menus have been found to enhance the nutritional status and academic performance <sup>[34]</sup>. These programs, when extended to early childcare facilities, can have long-term health effects on children.

### **Health education and community engagement**

Efforts on health education for children, parents, and other caregivers are extremely necessary. Counseling during healthcare visits should include information on portion control, meal planning, and the risks of sedentary behavior. Mothers' workshops and community workshops in general can help to increase knowledge regarding healthy nutrition and physical activity, promote healthy behavior since early childhood <sup>[45]</sup>. The introduction of health education in early childhood has proved to be effective. Children may be empowered using interactive modules on healthy eating, body image, and physical activity. Information should be disseminated consistently

based on evidence through schools and daycare centers <sup>[46]</sup>.

### **Sleep hygiene**

Sleep is vital for regulating hormones and metabolism. The lack of sleep also alters the ghrelin and leptin levels, contributing to the enhanced appetite and resulting in the rise of caloric consumption <sup>[47]</sup>. The American Academy of Pediatrics recommends 11–14 hours of sleep for children aged 1–2 years and 10–13 hours for those aged 3–5 years. Sleep hygiene should be a standard component of pediatric wellness visits. Interventions like regular bedtime routines, reducing screen time before bedtime, and parental education regarding the age-appropriate sleep needs are advised.

### **Medical and pharmacological management**

Although lifestyle modification is the mainstay of the prevention of obesity, drug intervention can be applied in severe obesity cases. The existing forms of treatment lack management among children, and most medications require special care under the concerned specialists. Lipase inhibitors, appetite suppressants, and leptin replacement therapies have proven to be only slightly effective and have to be combined with behavior interventions <sup>[48]</sup>. Bariatric surgery is never considered in younger children, but the technique is used in adolescents whose comorbidities are life-threatening and the conservative measures have failed. They involve sufficient psychological and medical assessment and follow-ups <sup>[49]</sup>.

### **Surveillance and early detection**

Regular surveillance is critical to identify at-risk children and initiate timely intervention. By coordination and combination with the assessment of parental BMI, eating habits, and physical activity, as well as similar periodic assessment of the BMI of children, a good profile of risk can be created <sup>[50]</sup>. Longitudinal monitoring and policy evaluation may be established with the help of establishing national

obesity registries and electronic health databases. In addition, medical professionals ought to be sensitized during training on how to speak about obesity without the stigma. It is possible to connect children with multidisciplinary teams in schools/professional early detection programs in primary care <sup>[51]</sup>.

### **Early infancy and perinatal care**

The condition of maternal health throughout pregnancy and infant care in the perinatal period plays a significant role in the risk of obesity in the child. It is essential to have proper maternal nutrition, controlled gestational weight gain, in addition to avoiding gestational diabetes <sup>[52]</sup>. Bottle feeding ought to be avoided where possible, and breastfeeding ought to become the normative accommodation. Doctors ought to advise pregnant women about nutrition, the positive effects of exercising during pregnancy, and nutritional postnatal measures. To enhance continuity of care during pregnancy to early childhood, it will be necessary to integrate the maternal and child health programs.

### **Policy and legislative interventions**

Governmental action plays an indispensable role in shaping environments conducive to healthy behaviors. Legislative policies must comprise a sugar-sweetened beverage tax, front-of-pack nutritional labeling, bans on advertisements that market unhealthy food to children, and subsidies on fruits and vegetables. Moreover, physical activity may be supported by investments in urban infrastructure, e.g., playgrounds, bicycling lanes, and walkways. Cases of Chile and the UK reveal excellent outcomes of advertising bans and warning labels, leading to low consumption of ultra-processed foods. There should also be frequent checks carried out by the governments on food quality, and clear labeling should also be followed, allowing consumers to make judicious choices <sup>[53]</sup>. There should also be a policy that brings healthy food procurement requirements to places of learning, hospitals, and daycares. These standards will normalize healthy eating habits

and lessen children's exposure to food rich in calories and low in nutrients.

### **Integrated multi-sectorial approach**

Given the complex etiology of childhood obesity, an integrated strategy involving health, education, agriculture, and urban planning sectors is essential. Synergy between policies and interventions can be facilitated by the coordination efforts of the sectors. In this way, interventional initiatives, such as school wellness programs, can be organized by ministries of health and education, whereas urban planners can create child-friendly settings that would promote active lifestyles. Sustainable behavioral change should be achieved through the activity of stakeholders like families, teachers, healthcare providers, and policymakers. More attention can be paid to overseeing, tracking, and optimizing strategic development with national task forces on childhood obesity. The deterrence as well as the treatment of obesity in children demands an active and evidence-based context-sensitive approach. Excessive interactions can be curbed by intervention at an early age via feeding of the infants, physical activity, health education, and adequate policy frameworks. Further, there must be continued surveillance, and the construction of public health facilities to have a long-term impact. Nations should rise up with firm actions to stop future generations from facing lifelong ramifications of early-onset obesity.

### **Recommendations and future directions**

The findings of this review point to the increasing burden of childhood obesity, with a large geographical difference among children under the age of five. Though the prevalence rate is alarmingly high and increasing in high-income countries like Qatar, Canada, and the US, in South Asian countries like India, Nepal, and Bangladesh, the prevalence rate is relatively low, but the signs of gradual increase can be noticed due to fast urbanization and changes in lifestyle. The etiology of childhood obesity, which is multifactorial, influenced by genetic

predisposition, socio-economic factors, diet, physical activity, and environmental exposure, should necessitate a multi-sectoral approach. These issues can be improved through concerted actions in the policy, health, education, and research sectors.

### **Policy recommendations**

Global, regional, and national policymakers should give priority to legislative interventions as a way to alleviate obesogenic contexts. The policies that encourage the accessibility of healthy foods, control the marketing of high-energy carbohydrates, and the subsidization of fruits, vegetables, and whole-grain foods should be enacted internationally by organizations such as the WHO, and should be enforceable. The introduction of fiscal measures, like sugar-sweetened beverages tax or low-calorie food products subsidies, which have proven effective in other countries like Mexico and the UK in particular, should be introduced in developing regions. City planners should aim at creating more recreational facilities, walking routes, and parks, attracting children to support physical activity. Strict regulations on labels and advertising bans targeting children should be applied. In countries of South Asia, the focus of the national food policy must be on the maintenance of traditional, less-processed diets, mass media courses, school nutritional information, and education.

### **Clinical and community-based interventions**

The interventions need to be developed during the stage of early infancy and ongoing in childhood, both at the community and the medical level. Exclusive breastfeeding with nutritional support, withholding of complementary food, and discouraging use of bottle feeding will go a long way in preventing obesity at an early age. Healthcare professionals must screen children by calculating BMI during normal check-ups at healthcare facilities; they also need to evaluate family health backgrounds and educate families about diet and exercise. Long-

term healthy behaviors can be taught through school-based interventions like fitness programs, structured play, and healthy eating workshops. Additionally, the education of the parents, especially women, is important to create a home environment in which healthy eating and physical exercise are encouraged. Public health campaigns should also emphasize limiting screen time to less than one hour per day for preschoolers, in accordance with WHO guidelines, and ensuring adequate sleep, which plays a vital role in metabolic regulation.

### **Research recommendations**

Future studies need to fill the big gaps in the knowledge about the region-specific determinants of childhood obesity. Longitudinal studies are needed to investigate genetic predispositions as well as endocrine and microbial factors, and the effects of prenatal and early exposures. Specifically, in South Asia, where malnutrition co-exists with the emergence of obesity, research ought to understand the double burden of obesity and undernutrition and design culturally adapted interventions. Moreover, the use of digital health solutions, mobile apps, and big data analytics can contribute to obesity surveillance and the personalization of intervention. Cross-national research would have the potential to identify effective measures in prevention and long-term management. Ultimately, to drive down the current trend of rising obesity among children, it may be necessary to invest more in early interventions, strong public health infrastructure, and inter-sectoral cooperation to establish environments in which children grow up to behave healthily in later life.

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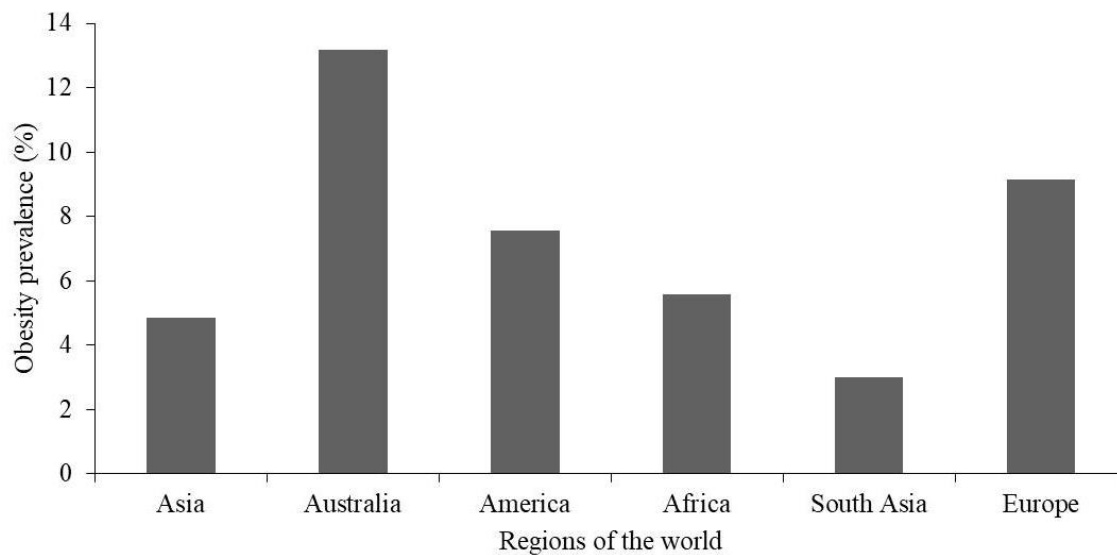


Figure 1: Worldwide prevalence of obesity (2000-2020)

The bar chart displays the average prevalence (%) of obesity in children under five years of age.

Australia experienced the highest prevalence of obesityglobal obesity pandemic: shaped by global

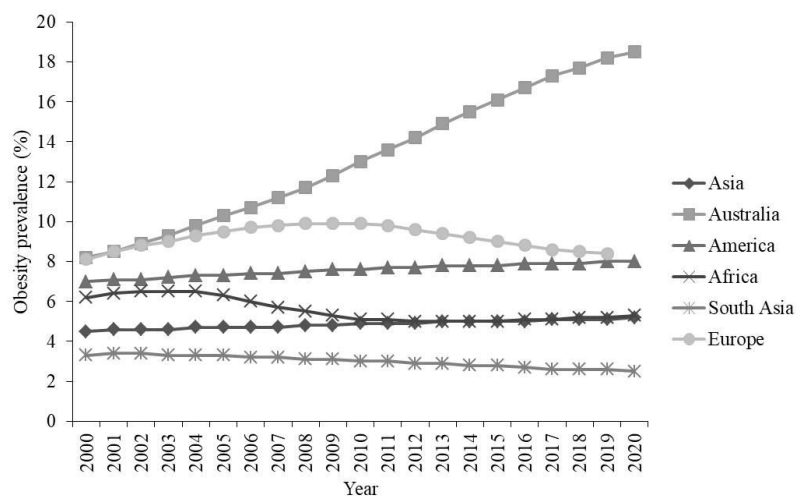


Figure 2: Trends towards the prevalence of childhood obesity from 2000 to 2020

The tendency towards obesity varies among different regions of the world. Australia exhibited a robust increase in obesity prevalence. South

Asia showed a decrease in the tendency of obesity prevalence

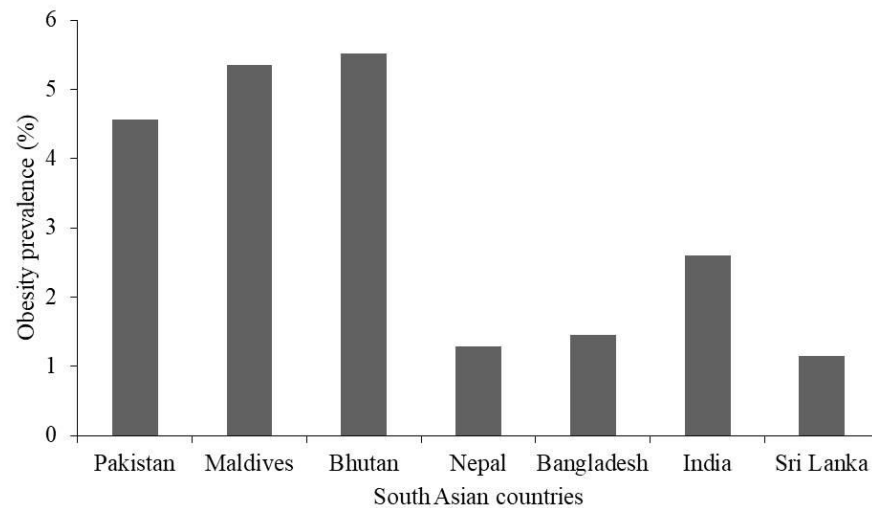


Figure 3. Prevalence of childhood obesity in South Asian countries

Bhutan and the Maldives had the maximum prevalence rates, followed by Pakistan. India,

Bangladesh, Nepal, and Sri Lanka reported low obesity prevalence

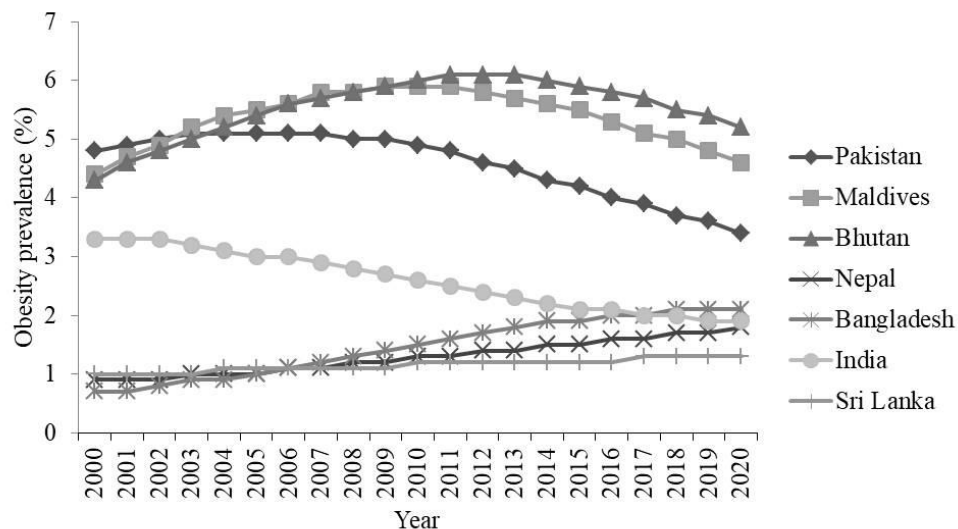


Figure 4: Trends towards the prevalence of childhood obesity in South Asian countries

Pakistan, the Maldives, and Bhutan exhibited an initial upsurge, followed by a steady decrease.

India experienced a gradual decline, whereas Bangladesh, Nepal, and Sri Lanka showed constant upward trends.

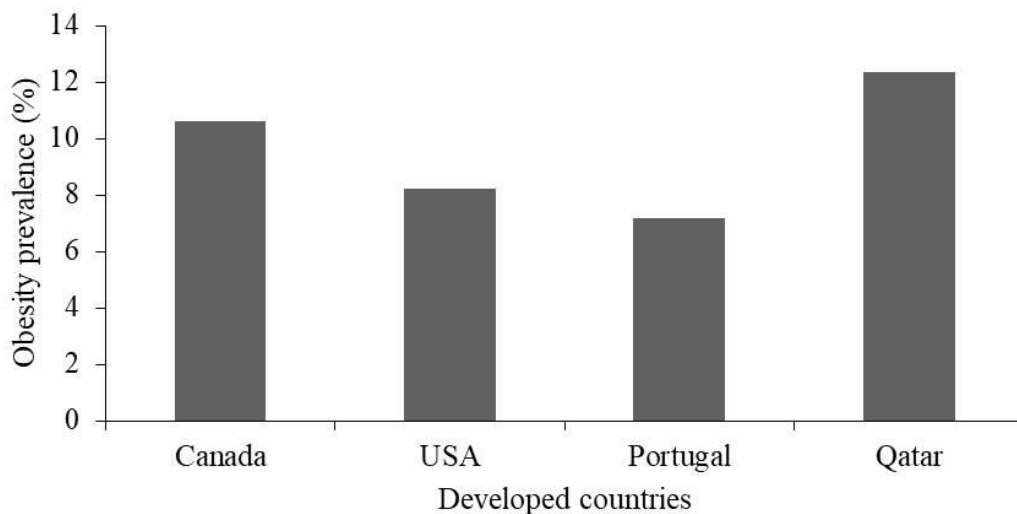


Figure 5: Prevalence of obesity in developed countries (2000-2020)

The bar chart shows the average prevalence of obesity among children under five years of age. Qatar recorded the maximum prevalence,

followed by Canada. The USA and Portugal reported relatively lower rates.

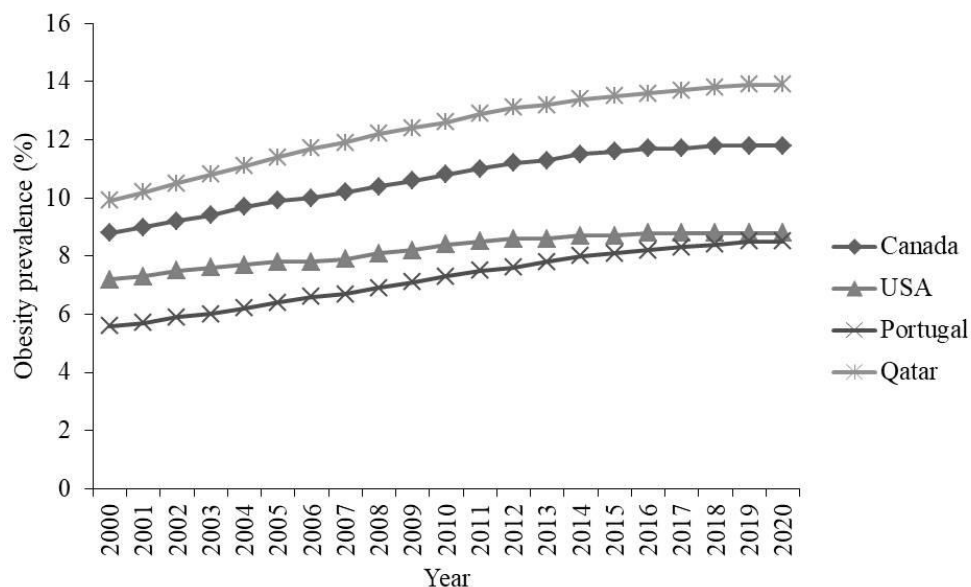


Figure 6: Trends towards childhood obesity prevalence in developed countries

Qatar and Canada reported the maximum and most consistent rise. The USA showed moderate

growth, whereas Portugal recorded the lowest rates with a continuous upward trend.