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The Influence of Ultra-Processed Food on Childhood Obesity: A Systematic Review

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Abstract

This study aims to evaluate the impact of ultra-processed food (UPF) consumption on the risk of obesity in children through a systematic review of studies published between 2019 and 2024. This article is using a Systematic Literature Review (SLR) method with the PRISMA approach, this study screened 319 articles from the Scopus database, ultimately selecting 13 relevant articles based on inclusion and exclusion criteria using the PICOC framework. A significant correlation exists between UPF consumption and childhood obesity risk. UPFs are associated with elevated BMI, increased waist circumference, nutrient deficiency, and addictive eating patterns. Socioeconomic status, educational setting, and advertising exposure exacerbate these adverse outcomes. The primary constraints encompass methodological discrepancies across the analyzed studies, an absence of longitudinal data, and restricted applicability of findings to developing nations. These findings endorse the development of evidence-based nutrition policies, including food labeling and UPF advertising restrictions for children. This research introduces a novel "3P" intervention framework (Product, Place, Promotion) for regulating UPF consumption, incorporating biological and social variables into a holistic analytical model.

Keywords: Ultra-processed Food, Childhood Obesity, Food Addiction, Dietary Patterns.

Introduction

In recent decades, dietary patterns have shifted towards increased consumption of ultra-processed foods (UPF) [1]. UPFs, which are high in sugar, saturated fats, and sodium while low in fiber, constitute up to 60% of children's daily calories in developed nations [2]. These products, rich in chemical additives and lacking in traditional ingredients, offer poor nutritional quality [3]. Furthermore, UPFs are associated with addictive eating behaviours that lead to excessive caloric intake [4]. This dietary change correlates with a threefold rise in childhood obesity prevalence—defined as a BMI at or above the 95th percentile per WHO standards since 1975, with UPF consumption recognized as a significant factor [5].

Conducting a systematic literature review (SLR) on ultra-processed food (UPF) consumption and childhood obesity is essential due to inconsistent evidence [6]. Some research indicates a significant increase in obesity risk linked to UPF consumption in children, while other studies present moderate effects [7]. The biological mechanisms involved are

intricate, with changes in gut microbiota and appetite regulation that are not fully elucidated [8]. Additionally, existing public health policies largely emphasize physical activity without sufficiently addressing UPF consumption reduction [9]. Thus, this SLR intends to consolidate current evidence, uncover patterns and determinants affecting the UPF-obesity nexus in children, and establish a robust basis for crafting more effective interventions and policies.

A systematic review identifies various strategies to address the influence of ultra-processed food (UPF) on childhood obesity. Regulatory measures, including a 20% sugar tax, can diminish UPF intake by 12%, thereby reducing obesity risk [10]. Furthermore, incorporating nutrition education in schools, such as the "Read UPF Labels" initiative, has enhanced children's nutritional knowledge by 35%, promoting healthier dietary choices [11]. An additional effective strategy involves providing subsidies for healthy foods, like vegetable vouchers, alongside restrictions on UPF advertising, resulting in an 18% decrease in childhood obesity rates in randomized trials [12]. Collectively, these fiscal policies, educational initiatives, and advertising regulations present a comprehensive approach to mitigating UPF consumption and its detrimental effects on child health [10].

This study significantly enhances public health and child nutrition by synthesizing evidence from 319 studies conducted between 2019 and 2024 [3]. It integrates findings on biological and social mechanisms linking ultra-processed food (UPF) consumption to childhood obesity and creates an intervention framework categorizing solutions by effectiveness [2]. The study proposes innovative policy recommendations using the "3P" approach (Product, Place, Promotion) to reformulate UPF products, regulate sales points, and control promotion to effectively reduce UPF consumption. Consequently, this research establishes a robust scientific basis for more targeted health intervention strategies and policies to combat the escalating childhood obesity crisis.

Method

The study aims to investigate the impact of ultra-processed food on childhood obesity using a systematic literature review (SLR) and PRISMA methodology. An SLR is a meticulous approach that systematically organizes existing research and establishes a basis for subsequent inquiries. [13] [14].

The process commences with the articulation of a precise research inquiry and the establishment of a protocol aimed at guaranteeing transparency and methodological rigor [14], [15]. An extensive literature review and screening are performed using strict criteria to identify relevant studies; however, this process may be time-consuming and prone to errors [16]. The phases involve quality assessment, data collection, and synthesis, often employing meta-evaluation techniques to provide an in-depth comprehension of significant elements beyond mere frequency analysis [17] [18]. Finally, the findings are disseminated in a systematic manner, guided by checklists to uphold clarity and precision [15].

The initial phase employs the PICOC framework delineated in Table 1 to facilitate the articulation of precise and targeted research inquiries, thereby guaranteeing that the systematic review is both thorough and systematic [19], [20].

Table 1. PICOC Framework

PICOC Component	Description
Population	Children
Intervention	Consumption of ultra-processed food
Comparison	Children with minimal or no consumption of ultra-processed food
Outcome	Risk or incidence of obesity in children
Context	Health field, studies published in health journals related to nutrition and childhood obesity

Source: Researcher, 2025

Following the identification of the relevant PICOC framework, the subsequent stage involves the formulation of research questions (RQ) that are derived from the PICOC framework to direct the review process [21]. In the present study, the RQs are categorized into four distinct groups, as delineated in Table 2.

Table 2. Request Question

ID	Research Question
RQ1	What is the effect of ultra-processed food consumption on the risk of obesity in children?
RQ2	Do children who consume ultra-processed foods have a higher risk of obesity compared to those who consume minimally processed foods?
RQ3	What factors influence the relationship between ultra-processed food consumption and childhood obesity?
RQ4	How can nutritional interventions mitigate the impact of ultra-processed food consumption on childhood obesity?

Source: Researcher, 2025

The selected database is Scopus, chosen based on a comprehensive assessment to optimize the literature search process. The search string used for literature retrieval is: (*ultra) AND (processed) AND (food) AND (obesity) AND (child*)*. Studies from the selected database are filtered based on titles, keywords, and abstracts.

Once the results are obtained, the next step is screening through a selection process using inclusion and exclusion criteria to identify literature relevant to the research objectives, such as country, source, language, and publication date [22] [23] [24]. The study's inclusion and exclusion criteria are outlined in Table 3. Additional processes, such as Title and Abstract Screening, filter studies based on preliminary information. Subsequently, Full-Text Screening entails a comprehensive evaluation of eligible studies, accompanied by Quality Assessment. Data extraction and management are conducted utilizing Zotero.

Table 3. Inclusion and Exclusion Criteria

Topic	Inclusion	Exclusion
Database	Scopus	All other databases
Time frame	2019 - 2024	Article published before 2019 and after 2024
Document type	Article	All other document article (e.g. Review, Conference paper, Book chapter and Book)
Language	English	Other languages
Subject area	Medicine	Other subject area

Topic	Inclusion	Exclusion
Publication stage	Final	Article in press
	Human, Child	
Keyword	Obesity	Another keyword
Source type	Journal	Book, Conference proceeding and Book series
Open Access	All open access	Green, Gold, Hybrid gold and Bronze

Source: Researcher, 2025

The final step in the second stage is to comprehensively describe all processes in detail using the PRISMA methodology [25] [26] [27] as illustrated in Figure 1. This methodology consists of three key phases: identification, screening, and inclusion.

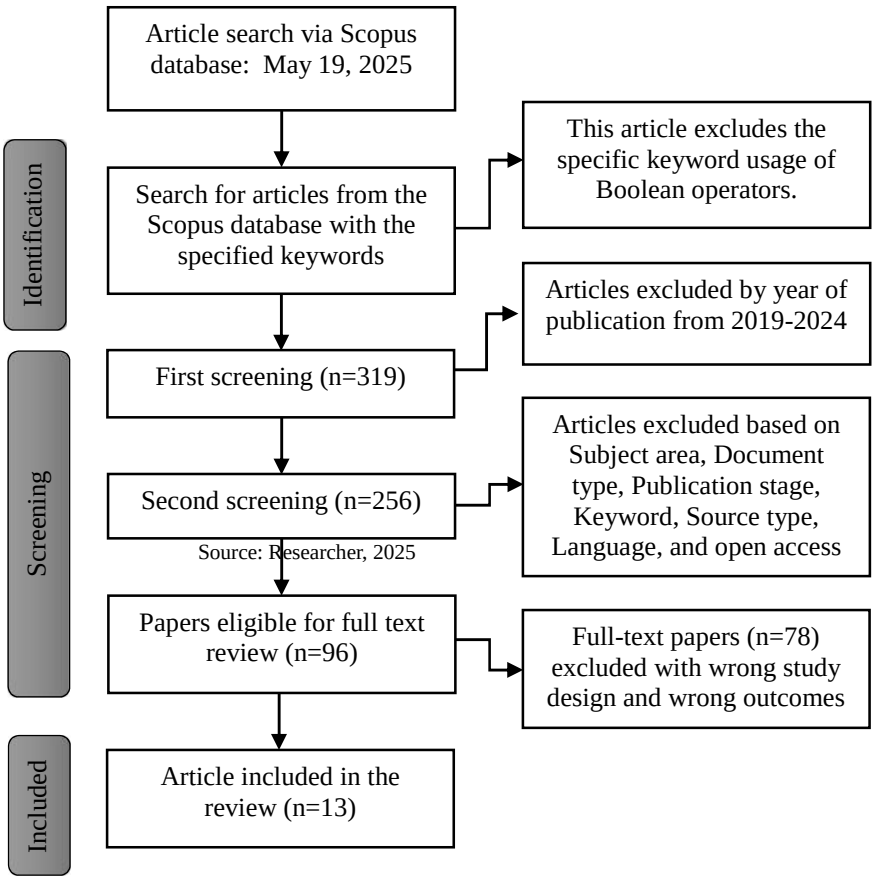

Figure 1. Systematic Literature Reviews information flow using PRISMA

Based on Figure 1, the initial stage entails keyword identification, retrieving 319 records. An initial screening follows, excluding studies by publication year, resulting in 256 records. A second screening phase refines the selection to 96 records. Ultimately, a full-text review is executed, producing 13 articles to validate the quality and credibility of the sources.

Results and Discussion

This study examines four research questions based on 13 articles from the Scopus database regarding ultra-processed food's impact on childhood obesity. The

data is derived from the analysis of published articles, their publication trends, and journal sources. Furthermore, this research aims to identify key factors related to ultra-processed food's effect on childhood, including authors, affiliations, countries involved, and its influence on childhood obesity. Here are several research findings that serve as references for this study.

Table…….

No	Author	Research Title	Methods Used	Result
1	Stefania et.al (2024)	Ultra-Processed Foods and Nutritional Intake of Children and Adolescents from Cantagalo, São Tomé and Príncipe	• A cross-sectional study was conducted as part of the MeNutRic Plus project. • A 24-hour food recall questionnaire was utilized for dietary assessment • The Goldberg method identified inaccurate dietary reports. • Logistic regression models analyzed associations between food consumption and nutritional intake	• The sample included 546 children with a mean age of 10.8 years. • 33.7% of children showed some form of thinness. • 4.4% of children were classified as overweight or obese. • Higher UPF consumption linked to lower fiber and vitamin intakes. • UPFs contributed 9.5% of energy intake for girls and 8.5% for boys
2	Laura et.al (2021)	Ultra-processed foods consumption and diet quality of European children, adolescents and adults: Results from the I.Family study	• Dietary intake was assessed using a 24-hour recall. • Ultra-processed foods were classified by NOVA. • Usual intakes were estimated with statistical models. • Key covariates included age, BMI, and sex.	• The study included 7,073 subjects, with 58% females. • UPFs provided over 50% of total fat and sugar intake in children, decreasing with age. • No UPF differences by education or income • Highest UPF intake in Belgium, Germany, Sweden. • Lowest HDAS in highest UPF group, indicating poor diet quality.
3	Wanjohi et.al (2025)	Ultra-Processed Food Consumption Is Associated with Poor Diet Quality and Nutrient Intake Among Adolescents in Urban Slums, Kenya	• A cross-sectional household study was conducted with 621 adolescents aged 10-19 years. • Descriptive statistics summarized socio-demographic characteristics and energy intake. • Multinomial logistic regression assessed factors associated with energy intake from UPFs. • Linear regression evaluated the association between %TEI from UPFs and diet quality. • Kruskal-Wallis tests analyzed differences in median nutrient intake across quartiles.	• UPFs contribute 25.2% to adolescents' daily energy intake. • Higher leisure screen time is linked to increased UPFs energy intake. • UPFs intake correlates with poor diet quality and nutrient intake. • 13% of adolescents were overweight/obese, lower than national averages.
4	Khoury et.al (2025)	Ultraprocessed Food Consumption and Cardiometabolic Risk Factors in Children	• Children aged 3–6 were recruited from seven Spanish centers between 2019 and 2022. • Parents provided consent and completed questionnaires on physical activity and diet. • UPF intake and cardiometabolic risk factors were analyzed using adjusted multivariable regression models	• The study involved 1,426 children (mean age 5.8 years; 49% boys, 51% girls). • Higher consumption of ultra-processed foods (UPFs) was linked to increased BMI, waist circumference, fat mass index, and fasting plasma glucose levels. • Children with the highest UPF intake showed lower HDL cholesterol levels, while their mothers tended to be younger and have lower education levels
5	Bellucci et.al (2023)	The impact of food addiction behaviours on the treatment of overweight students	• A within-subjects design was adopted for dietary recommendations and treatment. • The Yale Food Addiction Scale for Children assessed food addiction.	• The study involved 120 overweight students aged 9-11 years. • Food addiction (FA) was present in 33.4% of assessments.

No	Author	Research Title	Methods Used	Result
			• A semi-quantitative FFQ evaluated food consumption at baseline and after 16 months. • Linear mixed-effects models analyzed changes in BMI/age z-score over time.	• FA influenced weight maintenance during the intervention. • Non-FA students showed weight loss; FA students did not. • Sugary drink consumption decreased significantly in non-FA students
6	Zancheta et.al (2024)	The consumption of ultra-processed foods was associated with adiposity, but not with metabolic indicators in a prospective cohort study of Chilean preschool children	• Dietary data collected using 24-hour recalls at age 4 years. • Usual consumption of UPF estimated using the Multiple Source Method. • Statistical analysis included linear regression models for associations. • Inverse probability of censoring weights was applied to adjust analyses. • Metabolic indicators measured through blood samples after fasting	• Higher UPF consumption was linked to increased adiposity indicators in children. • No association was found between UPF and metabolic outcomes. • The study involved 962 Chilean preschool children over two years. • The results suggest that changes in adiposity indicators may precede alterations in metabolic markers in young children.
7	Ães et.al (2024)	Patterns of ultra-processed foods consumption throughout childhood and trajectories of growth and adiposity	• Food frequency questionnaires (FFQs) assessed dietary intake at 4, 7, and 10 years. • FFQs were validated using 3-day food diaries for accuracy. • Model-based clustering defined UPF consumption patterns using a Gaussian mixture model. • Mixed-effects models analyzed outcome trajectories adjusted for confounders.	• Four UPF consumption patterns were identified: lower, intermediate, transition, and higher. • Constantly higher UPF consumption linked to worse growth and adiposity trajectories. • Higher UPF consumption resulted in greater body weight acceleration. • BMI z-score increased more significantly with higher UPF consumption. • Early interventions to limit UPF consumption are essential for growth
8	Clemente et.al (2024)	Higher consumption of ultra-processed foods and a pro-inflammatory diet are associated with the normal-weight obesity phenotype in Brazilian children	• Cross-sectional study with 364 children aged 8–9 years. • Three 24-hour dietary recalls evaluated NOVA classification groups and C-DII scores. • Poisson regression models assessed associations of UPF consumption and C-DII with NWO. • Multivariable linear regression models adjusted for sex, age, income, and screen time.	• The study involved 364 children aged 8 to 9 years. • 18% of participants exhibited the normal-weight obesity (NWO) phenotype. • Higher family income was associated with the NWO group. • Increased ultra-processed food consumption linked to higher NWO prevalence.
9	Duque et.al (2022)	Evidence of Unhealthy Dietary Patterns in the School Lunch Sent from Home for Children in Mexico City	• Cross-sectional study involving schoolchildren from four elementary schools in Mexico City. • Fasting venous blood samples collected to assess metabolic parameters. • Dietary patterns identified using K-means clustering based on school lunch contents. • Statistical analyses included Kruskal-Wallis and Pearson's chi-squared tests.	• Among 350 schoolchildren (mean age 7.9 years), 24.9% were overweight and 21.7% obese. • Four dietary patterns were identified from school lunches, with the highest calories from sandwiches, tortas, and sweetened dairy products (657 kcal). • The median energy intake from school lunches was 448 kcal, and no dietary pattern was considered healthy due to high sugar content. • Most children (89.4%) brought lunch from home, highlighting the need for better caloric distribution in meals.
10	Carvalho et.al (2022)	Development and validation of a food frequency questionnaire for	• A cross-sectional study was conducted with 130 children aged 7 to 10 years.	• 95% of consumed foods were ultra-processed, including packaged snacks and powdered juice.

No	Author	Research Title	Methods Used	Result
		children aged 7 to 10 years	• An 81-item food frequency questionnaire was developed for the study. • Validity was assessed by comparing with 24-hour dietary recalls. • Reproducibility was evaluated using two food frequency questionnaires.	• Significant correlation coefficients for lipids (0.45) and carbohydrates (0.37). • After energy adjustment, calcium correlation increased to 0.75; protein and lipid correlations were moderate. • Recent study found 24% of children aged 7-10 were overweight. • Food frequency questionnaire (FFQ) showed good calibration with reference methods, no systematic bias.
11	Filgueiras et.al (2023)	Characteristics of the obesogenic environment around schools are associated with body fat and low-grade inflammation in Brazilian children	• Linear regression models assessed associations between obesogenic environment and body adiposity. • Generalised estimating equations were used for statistical analysis. • Body adiposity was measured using dual-energy X-ray absorptiometry (DXA). • Concentrations of adipokines were analyzed from blood samples	• The mean age of participants was 8.5 years, with 52.1% being girls. • Average total body fat percentage was 24.2%, with android fat at 17.7%. • A positive association was found between the density of ultra-processed food stores and total body fat. • The study assessed the impact of the urban environment on children's adiposity and adipokine levels.
12	Chang et.al (2021)	Association Between Childhood Consumption of Ultraprocessed Food and Adiposity Trajectories in the Avon Longitudinal Study of Parents and Children Birth Cohort	• Linear growth curve models assessed UPF quintile and adiposity outcomes. • Multiple imputation addressed missing covariate data. • Stepwise adjustment for covariates in analytical models. • Quadratic age term evaluated nonlinearity in growth models. • Study followed children from 7 to 24 years	• Higher UPF consumption is linked to increased adiposity in children. • Results remained consistent after excluding dietary misreporters. • Longitudinal associations were analyzed from ages 7 to 24. • Multiple imputation addressed missing data bias.
13	Letícia et.al (2024)	Nutritional Status and Food Consumption of Preschool-age Children: An Observational Cross-Sectional Study Carried Out in Schools Covered by the Brazilian School Feeding Program	• Anthropometric measurements were taken to assess weight and height. • Body Mass Index (BMI) was calculated using WHO standards. • A validated food frequency questionnaire collected data on food consumption. • Statistical analyses were performed using R software.	• The study included 153 children: mostly aged 4 to 5 years old. • 35% of participants were classified as overweight or at risk of overweight. • Low vegetable consumption was reported among the children. • High intake of ultra-processed foods was observed. • A significant association was found between BMI and triceps skinfold thickness.

RQ1: What is the effect of ultra-processed food consumption on the risk of obesity in children?

The rise in ultra-processed food consumption among children has heightened concerns regarding obesity risk. UPFs are characterized by high levels of sugars and unhealthy fats, coupled with low nutrient density. This dietary trend is associated with numerous health complications, notably obesity in children. Ultra-processed foods (UPFs) are defined by their elevated energy density, frequently comprising substantial quantities of sugars, fats, and sodium, which may result in augmented caloric consumption and subsequent weight gain. In pediatric populations, an increased intake of UPFs has been correlated with diminished consumption of vital nutrients such as dietary fiber, vitamins, and minerals, all of which are essential for optimal growth and development [28].

Studies indicate that children consuming high amounts of UPFs tend to have higher body mass index (BMI) z-scores and waist circumference, suggesting a direct link between UPF intake and obesity [29]. Some studies suggest that the consumption of UPFs may be linked to food addiction behaviours, which can further exacerbate overeating and weight gain, and Children with food addiction tendencies showed higher consumption of energy-dense UPFs, indicating a potential cycle of unhealthy eating habits [30].

RQ2: Do children who consume ultra-processed foods have a higher risk of obesity compared to those who consume minimally processed foods?

The intake of ultra-processed foods (UPFs) among children has emerged as a considerable concern owing to its possible correlation with obesity and various other health-related complications. UPFs are characteristically elevated in sugars, detrimental fats, and artificial additives, while simultaneously being deficient in vital nutrients. This analysis investigates the association between UPF intake and obesity susceptibility in children in contrast to those who consume minimally processed foods.

UPFs are associated with a lower intake of essential nutrients such as fiber, vitamins, and minerals. For instance, higher UPF consumption was linked to a lower intake of fiber, vitamin B12, and zinc, while showing a higher intake of iron and sodium [28]. The prevalence of UPF consumption among children is concerning, as it often replaces healthier food options. For example, in a cohort study, children with higher UPF consumption had lower intakes of fruits, vegetables, and fiber-rich foods, which are crucial for healthy growth and development [31]. The consumption of UPFs has been shown to correlate with increased energy density in diets, which can lead to excessive calorie intake and weight gain.

Research demonstrates that children exhibiting elevated consumption of ultra-processed foods (UPF) show increased body mass index (BMI) z-scores alongside a higher incidence of overweight and obesity. For example, children categorized within the upper tertile of UPF consumption displayed markedly greater BMI and waist circumference when juxtaposed with those residing in lower tertiles [29]. Longitudinal research has substantiated that persistent elevated intake of ultra-processed foods during the developmental stages of childhood correlates with expedited weight gain and an augmented fat mass index, indicating a direct association with the risk of obesity.

Other determinants contributing to the excessive consumption of ultra processed foods (UPFs) among children encompass socio-economic variables. The intake of UPFs is frequently elevated among children hailing from lower socioeconomic strata, where the availability of nutritious food alternatives is severely constrained. This demographic pattern intensifies the susceptibility to obesity within these groups [29].

RQ3: What factors influence the relationship between ultra-processed food consumption and childhood obesity?

The correlation between the consumption of ultra-processed foods (UPF) and the incidence of childhood obesity is modulated by a multitude of determinants, encompassing dietary habits, socioeconomic variables, and the nutritional integrity of ingested food items. Grasping these determinants is imperative for the formulation of efficacious public health initiatives aimed at mitigating childhood obesity.

The heightened consumption of ultra-processed foods (UPFs) exhibits a robust

correlation with increased energy density and diminished nutritional quality, which collectively augment the risk of obesity among children. UPFs are characteristically abundant in sugars, fats, and sodium, resulting in excessive caloric intake and subsequent weight gain.

Furthermore, an elevated consumption of UPFs is associated with a reduced intake of vital nutrients, including fiber, vitamins, and minerals. For instance, children who exhibit a higher consumption of UPFs generally demonstrate significantly lower levels of fiber, vitamin B12, and zinc—nutrients that are indispensable for optimal growth and development. The substitution of nutrient-dense food items with energy-dense, nutrient-deficient UPFs further intensifies the obesity risk, underscoring the detrimental effects of UPFs on overall dietary quality and health outcomes [28] [29] [32].

Economic variables significantly influence the consumption patterns of ultra-processed foods (UPFs), particularly among children hailing from disadvantaged socioeconomic environments, as these goods are frequently more economically accessible and widely available. This demographic phenomenon correlates strongly with elevated obesity prevalence within this cohort. Furthermore, the level of education—particularly maternal educational attainment—exerts a considerable effect on dietary selections, as mothers possessing lower levels of educational achievement are inclined to have offspring with increased UPF consumption, which is concomitant with a heightened risk of obesity. Another external determinant contributing to this dilemma is the marketing and accessibility of UPFs. These products are subject to vigorous marketing strategies targeting children, rendering them more attractive and readily obtainable. Such marketing methodologies can significantly influence dietary inclinations and propel higher consumption rates, especially within low-income households, thereby further intensifying the risk of childhood obesity [29].

Psychological determinants and habitual practices significantly influence the dietary patterns associated with ultra-processed foods (UPFs), primarily due to their appealing taste and convenient accessibility, which may foster compulsive eating behaviours, thereby complicating children's ability to manage their dietary consumption. As a result, this phenomenon can lead to an overconsumption of these foods and subsequent weight gain. Additionally, the inherent structural characteristics of UPFs, including their diminished fiber content, can interfere with satiety signalling, ultimately exacerbating overall food intake [33].

RQ4: How can nutritional interventions mitigate the impact of ultra-processed food consumption on childhood obesity?

The first, education and school intervention. Nutritional education programs enhance awareness of the adverse health effects of ultra-processed foods (UPFs), particularly their association with obesity and chronic diseases like type 2 diabetes and cardiovascular conditions. Through educating children and parents on the advantages of whole foods and the dangers of UPFs, families can make better-informed dietary decisions. School-based nutritional interventions promote minimally processed food consumption. Participation in structured programs correlates with decreased ultra-processed food intake and increased consumption of fruits, vegetables, and whole grains [30] [31] [34].

The second, policy and environmental changes. Policies promoting healthy food

access in low-income regions can effectively decrease children's intake of ultra-processed foods (UPFs). Programs like community gardens and farmers' markets can supply fresh produce and foster healthier dietary practices. Restricting UPF marketing to children may mitigate their intake of unhealthy foods. This entails controlling advertisements on various media to prevent promotion of health-risk products to children [31] [32].

The third, addressing food addiction. The significance of food addiction in ultra-processed food consumption is essential. Targeted interventions can facilitate healthier food relationships in children. Integrating psychological support with nutritional education may improve weight management efficacy [34].

The fourth, promoting healthy eating habits. Promoting family meals and home cooking can enhance nutrition and decrease dependence on ultra-processed foods (UPFs). Implementing strategies like meal planning and preparation can assist families in circumventing UPFs, resulting in improved dietary selections [30].

Conclusion

The findings of this systematic review demonstrate a significant correlation between ultra-processed food (UPF) consumption and elevated obesity risk in children. UPFs, noted for their high sugar, saturated fat, and sodium content, alongside low fiber and nutrient levels, are pivotal in promoting excessive caloric intake and suboptimal dietary quality in the pediatric population. In contrast to their counterparts consuming minimally processed foods, children with high UPF intake show increased body mass index (BMI) and waist circumference. Additionally, elements such as food addiction, low socioeconomic status, and exposure to unhealthy food marketing intensify UPF consumption and heighten susceptibility to childhood obesity.

Comprehensive nutritional interventions effectively alleviate the adverse effects of UPF consumption on childhood obesity. Nutrition education within schools and families can enhance awareness of UPF risks and promote healthier food choices. Moreover, policy measures limiting UPF marketing to children and improving access to nutritious foods in low-income areas are essential for addressing nutritional inequalities. The incorporation of psychological strategies to counteract UPF addiction, in conjunction with the encouragement of healthy eating practices like home cooking and family meals, is promising for reducing childhood obesity rates and improving nutritional quality.

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