

Obesity in Children: Genetic Susceptibility, Nutritional Counseling, and Nursing Role in Prevention

Saleha Mehzam Alenaizi¹, Badryah Marzouq Fehaid Albulaitih², Bushra Eissa Nahar Alhadbani², Manal Obaid Shujaa Alamri³, Thayibah Sayfi Mishkhas Almutairi³, Naifah Saleh Salem Alshammari⁴, Najlah Jubair Mudhi Aldhafferi¹, Bashayr Hirbid Shawan Aldhafferi¹, Manal Dhafer Saqer Alanazi⁵, Hind Abdulrahman Ahmed Al Ateeq⁶

1. ksa, ministry of ministry, Maternity and Children's Hospital
2. ksa, ministry of ministry, Directorate of Health Affairs in Hafar Al-Batin
3. ksa, ministry of ministry, Hafr Albatin Health Cluster
4. ksa, ministry of ministry, Public Health South Khalidiya Health Center
5. ksa, ministry of ministry, Primary Health Care Center, Alсахafa
6. ksa, ministry of ministry, Eradah Complex for Mental Health

ABSTRACT

Background: Childhood obesity is a growing global health concern with complex effects on physical, emotional, and social well-being. Genetic predisposition, environmental influences, and lifestyle choices significantly enhance the likelihood of developing chronic diseases, including diabetes, cardiovascular conditions, and psychological disorders in later life. Progress in genomics has revealed significant genetic markers linked to obesity, including those that affect appetite regulation, energy expenditure, and lipid metabolism. Comprehending these genetic foundations is essential for customizing effective preventive measures. Nutritional counseling, especially when focused on family involvement and cultural sensitivity, has become fundamental in the management and prevention of pediatric obesity. Nurses, as primary healthcare providers, are distinctly equipped to incorporate these methods into comprehensive care plans, offering information, support, and advocacy for impacted children and their families.

Aim: This paper aims to clarify the influence of genetic predisposition on pediatric obesity, assess the effectiveness of dietary counseling in reducing its risks, and emphasize the essential nursing interventions that can assist in its prevention and management.

Methods: A comprehensive review of existing literature was performed, analyzing genetic determinants of childhood obesity, the effects of nutritional counseling interventions, and the involvement of nurses in education, early screening, and community-based prevention strategies. Peer-reviewed publications, clinical recommendations, and evidence-based studies were integrated to offer a multidisciplinary viewpoint on the subject.

Saleha Mehzam Alenaizi, Badryah Marzouq Fehaid Albulaitih, Bushra Eissa Nahar Alhadbani, Manal Obaid Shujaa Alamri, Thayibah Sayfi Mishkhas Almutairi, Naifah Saleh Salem Alshammari, Najlah Jubair Mudhi Aldhaffeei, Bashayr Hirbid Shawan Aldhaffeei, Manal Dhaher Saqer Alanazi, Hind Abdulrahman Ahmed Al Ateeq

Results: Genetic predisposition to obesity is facilitated by various factors, including alterations in the FTO gene, leptin signaling pathways, and polygenic effects on appetite control and metabolism. Epigenetic variables, including maternal nutrition and environmental influences, further influence these genetic predispositions. Nutritional counseling, which includes family involvement and behavioral adjustment, has shown considerable advantages in cultivating healthier eating practices and facilitating long-term weight management. Nurses play a significant role in obesity prevention by identifying at-risk children via early screening, delivering culturally appropriate educational programs, pushing for policy reforms, and executing community-level interventions that tackle socioeconomic obstacles to healthy living.

Conclusion: Childhood obesity embodies a multifaceted interaction of hereditary and environmental influences necessitating comprehensive preventative methods. Nursing treatments can significantly reduce the increasing prevalence of childhood obesity by addressing genetic predispositions and utilizing appropriate nutritional guidance. The distinctive role of nurses in healthcare systems enables them to deliver individualized, community-oriented treatment that fosters enduring behavioral modifications. Ongoing investigation into the genetic underpinnings of obesity and the enhancement of nursing practices will augment the efficacy of preventative initiatives and elevate long-term health outcomes for children globally.

KEYWORDS: childhood obesity, genetic susceptibility, nutritional counseling, nursing interventions, prevention, epigenetics, public health.

1. Introduction

Childhood obesity has become a significant global public health issue, with its incidence increasing at an alarming rate in recent decades. The World Health Organization (WHO) indicates that the prevalence of overweight or obese children aged 5–19 has surged from 4% in 1975 to over 18% in 2016, reflecting a substantial upward trend [1]. The rise in childhood obesity correlates with numerous detrimental health consequences, such as a heightened risk of type 2 diabetes, cardiovascular diseases, and different psychosocial problems in both childhood and adulthood.

The causes of childhood obesity are multifaceted, including genetic predispositions, environmental variables, and behavioral impacts. Recent breakthroughs in genomics have uncovered certain genetic variants that influence obesity susceptibility, including polymorphisms in the FTO gene and mutations impacting leptin signaling pathways [3]. Genetic variables interact with environmental aspects, such as eating habits and physical activity levels, to affect the probability of obesity development in children [4].

Nutritional counseling is acknowledged as a crucial element in the prevention and management of pediatric obesity. Evidence-based guidelines underscore the significance of family-centered strategies that foster healthy eating habits and lifestyle changes [5]. These interventions aim to modify dietary patterns that lead to excessive weight gain and to establish sustainable behaviors that can reduce obesity-related health risks [6].

Nurses are integral to the interdisciplinary initiatives addressing pediatric obesity. Their duties include health education, early screening for obesity risk factors, and the execution of community-based prevention activities [7]. Nurses can utilize their distinctive role within healthcare systems to advocate for and implement interventions that foster healthy growth and development in children [8].

This research seeks to examine the genetic determinants of childhood obesity, assess the impact of nutritional counseling on its prevention, and underscore the nursing interventions critical for tackling this widespread health concern. By synthesizing knowledge from genetics, nutrition, and nursing practice, we aim to deliver a thorough comprehension of the solutions required to mitigate the growing prevalence of childhood obesity.

Genetic Factors in Childhood Obesity

Childhood obesity is a multifaceted condition influenced by an interplay of genetic, environmental, and behavioral factors. Advancements in genomics have elucidated several genetic pathways that contribute to obesity susceptibility, including variations in the leptin and leptin receptor genes, the FTO (Fat Mass and Obesity-Associated) gene, and other polygenic influences affecting metabolism and fat storage. Additionally, epigenetic modifications, such as maternal diet and lifestyle during pregnancy, along with environmental triggers, can alter gene expression, further impacting obesity risk. However, translating these genetic findings into clinical practice presents challenges, and ethical considerations arise regarding genetic testing for obesity risk in children.

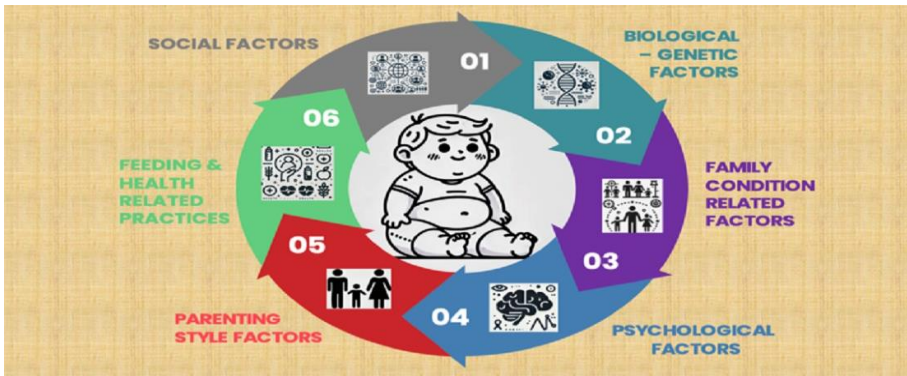


Figure 1 Childhood Obesity

Genetic Pathways and Susceptibility

Leptin and Leptin Receptor Genes

Leptin, a hormone predominantly produced by adipocytes, plays a crucial role in regulating energy balance by inhibiting hunger, thereby modulating body weight. Mutations in the leptin gene (LEP) or its receptor (LEPR) can lead to leptin deficiency or resistance, resulting in hyperphagia and severe early-onset obesity [9]. Studies have demonstrated that individuals with congenital leptin deficiency exhibit marked obesity from a young age, underscoring the hormone's significance in

Saleha Mehzam Alenaizi, Badryah Marzouq Fehaid Albulaitih, Bushra Eissa Nahar Alhadbani, Manal Obaid Shujaa Alamri, Thayibah Sayfi Mishkhas Almutairi, Naifah Saleh Salem Alshammari, Najlah Jubair Mudhi Aldhafferi, Bashayr Hirbid Shawan Aldhafferi, Manal Dhaher Saqer Alanazi, Hind Abdulrahman Ahmed Al Ateeq

appetite regulation [10].

FTO Gene and Appetite Control

The FTO gene, located on chromosome 16q12.2, has been identified as a significant genetic determinant of obesity. Variants within this gene are associated with increased body mass index (BMI) and a predisposition to both childhood and adult obesity [11]. Research indicates that individuals carrying risk alleles of the FTO gene exhibit higher caloric intake and a preference for energy-dense foods, suggesting a role in appetite control and energy homeostasis [12].

Polygenic Contributions Affecting Metabolism and Fat Storage

Beyond single-gene mutations, obesity is influenced by multiple genetic variants that collectively affect metabolic pathways and fat storage. Genome-wide association studies (GWAS) have identified numerous loci associated with BMI and adiposity, implicating genes involved in lipid metabolism, adipogenesis, and energy expenditure [13]. For instance, polymorphisms in the melanocortin-4 receptor (MC4R) gene are linked to increased appetite and reduced energy expenditure, contributing to obesity risk [14].

Epigenetic Modifications

Influence of Maternal Diet and Lifestyle During Pregnancy

Epigenetic modifications refer to heritable changes in gene expression without alterations in the DNA sequence. Maternal nutrition and lifestyle during pregnancy can induce epigenetic changes in the offspring, affecting their susceptibility to obesity. For example, maternal overnutrition or gestational diabetes can lead to DNA methylation changes in genes regulating appetite and metabolism, predisposing children to increased adiposity [15].

Environmental Triggers Modifying Gene Expression

Environmental factors, such as exposure to endocrine-disrupting chemicals, physical inactivity, and high-fat diets, can modify gene expression through epigenetic mechanisms. These modifications may alter metabolic pathways, leading to increased fat storage and obesity. Studies have shown that early-life exposure to obesogenic environments can result in lasting epigenetic changes that influence obesity risk [16].

Limitations and Ethical Concerns

Challenges in Translating Genetic Findings into Clinical Practice

While genetic research has advanced our understanding of obesity, integrating these findings into clinical practice remains challenging. The polygenic nature of obesity means that individual genetic variants confer modest risk, making it difficult to develop predictive genetic tests with high sensitivity and specificity. Moreover, the interaction between genetic predisposition and environmental factors complicates the development of targeted interventions [17].

Ethical Considerations in Genetic Testing for Obesity Risk in Children

Genetic testing for obesity risk in children raises ethical concerns, including issues of consent, potential stigmatization, and psychological impact. The utility of such testing is debated, given the current limitations in predictive accuracy and the availability of effective interventions. Ethical guidelines recommend that genetic testing in children should be approached with caution, ensuring that it is conducted in the best interest of the child and accompanied by appropriate counseling [18].

Nutritional Counseling as a Preventive Strategy

Childhood obesity is a multifaceted health issue influenced by genetic, environmental, and behavioral factors. Nutritional counseling emerges as a pivotal preventive strategy, encompassing family-centered approaches, behavioral modifications, school and community involvement, and technological innovations. This comprehensive approach aims to instill sustainable healthy eating habits and lifestyles in children and adolescents.

Family-Centered Approaches

Engaging Parents and Caregivers in Dietary Changes

The family unit significantly influences children's dietary behaviors. Engaging parents and caregivers in nutritional counseling fosters a supportive environment conducive to healthy eating. Studies indicate that parental involvement in dietary interventions enhances children's adherence to nutritional guidelines and promotes positive health outcomes [19]. Educational programs that equip parents with knowledge about balanced diets and meal preparation can lead to healthier family eating patterns [20].

Addressing Cultural and Socioeconomic Barriers to Healthy Eating

Cultural preferences and socioeconomic status profoundly impact dietary choices. Tailoring nutritional counseling to respect cultural food practices while promoting healthy alternatives is essential. Additionally, addressing socioeconomic barriers, such as limited access to affordable healthy foods, is crucial. Community-based programs that provide resources and education to low-income families have demonstrated effectiveness in improving dietary habits among children [21].

Behavioral Strategies

Encouraging Portion Control and Mindful Eating Habits

Behavioral strategies, including portion control and mindful eating, are integral to nutritional counseling. Teaching children to recognize hunger and satiety cues helps prevent overeating. Mindful eating practices encourage individuals to focus on the sensory experience of eating, promoting better food choices and reducing impulsive eating behaviors [22].

Promoting Balanced Diets Rich in Fruits, Vegetables, and Whole Grains

Emphasizing the consumption of fruits, vegetables, and whole grains is fundamental in preventing obesity. Nutritional counseling should focus on incorporating these food groups into daily meals. Interventions that include hands-on activities, such as cooking classes and gardening, have been effective in increasing children's intake of

Saleha Mehzam Alenaizi, Badryah Marzouq Fehaid Albulaitih, Bushra Eissa Nahar Alhadbani, Manal Obaid Shujaa Alamri, Thayibah Sayfi Mishkhas Almutairi, Naifah Saleh Salem Alshammari, Najlah Jubair Mudhi Aldhafferi, Bashayr Hirbid Shawan Aldhafferi, Manal Dhaher Saqer Alanazi, Hind Abdulrahman Ahmed Al Ateeq

these nutritious foods [23].

Role of Schools and Communities

School-Based Programs Integrating Nutrition Education

Schools serve as critical venues for implementing nutritional interventions. Integrating nutrition education into the curriculum and providing healthy meal options can positively influence children's eating behaviors. Programs that combine classroom instruction with practical experiences, such as taste tests and meal planning, have shown success in promoting healthy eating habits among students [24].

Community Initiatives to Increase Access to Healthy Food

Community-level initiatives, including farmers' markets, community gardens, and food assistance programs, enhance access to healthy foods. Collaborations between local governments, non-profit organizations, and businesses can create environments that support healthy dietary choices. Such initiatives have been associated with improved dietary behaviors and reduced obesity rates in children [25].

Technology and Innovations

Apps and Digital Platforms for Tracking Diet and Physical Activity

The advent of technology offers innovative tools for nutritional counseling. Mobile applications and digital platforms that track dietary intake and physical activity provide real-time feedback and personalized recommendations. These tools can engage children and adolescents in monitoring their health behaviors, leading to improved dietary habits and increased physical activity levels [26].

Gamification in Promoting Healthy Eating Behaviors

Gamification, the application of game-design elements in non-game contexts, has been utilized to promote healthy eating among children. Interactive games that reward healthy food choices and physical activity can motivate behavior change. Research indicates that gamified interventions can enhance engagement and adherence to nutritional guidelines in pediatric populations [27].

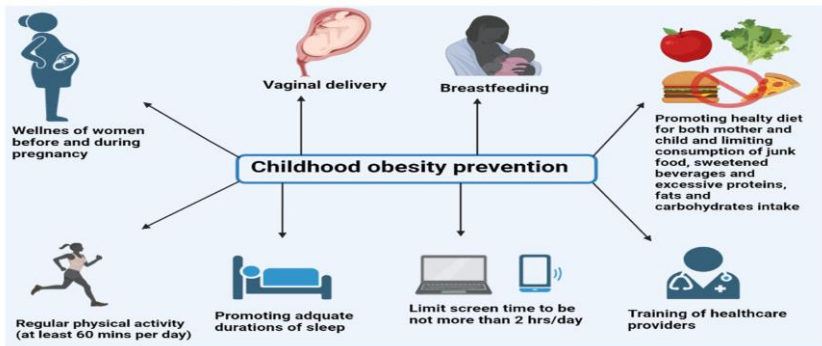


Figure 2 Prevention Childhood Obesity

Role of Nursing in Obesity Prevention

Nurses play a pivotal role in the prevention and management of childhood obesity through health education, early screening, community engagement, and advocacy. Their multifaceted involvement is crucial in addressing this complex public health issue.

Health Education and Counseling

Educating Children and Families on Healthy Dietary Habits and Physical Activity

Nurses are instrumental in imparting knowledge about balanced nutrition and the importance of regular physical activity. By providing tailored education to children and their families, nurses can promote the adoption of healthy eating patterns and active lifestyles. Studies have shown that nurse-led educational interventions significantly improve dietary behaviors and increase physical activity levels among children [28].

Providing Guidance on Reducing Screen Time and Sedentary Behavior

Excessive screen time is associated with sedentary behavior, contributing to obesity. Nurses counsel families on setting appropriate limits for screen use and encourage engagement in physical activities. Interventions focusing on reducing screen time have been effective in decreasing sedentary behavior and improving health outcomes in pediatric populations [29].

Early Screening and Risk Assessment

Monitoring Body Mass Index (BMI) and Growth Patterns

Regular monitoring of BMI and growth trajectories enables nurses to identify deviations from healthy patterns early. Early detection allows for timely interventions to prevent the progression of overweight to obesity. Implementing routine BMI assessments in clinical practice is recommended for effective obesity prevention [30].

Identifying At-Risk Children Through Family History and Lifestyle Evaluation

Assessing family history and lifestyle factors helps nurses identify children at higher risk for obesity. Understanding genetic predispositions and environmental influences allows for personalized counseling and targeted preventive measures. Comprehensive risk assessments are essential components of obesity prevention strategies [31].

Community and School Engagement

Organizing Workshops for Parents and Educators on Obesity Prevention

Nurses collaborate with schools and community organizations to conduct workshops that educate parents and educators about obesity prevention. These programs focus on nutrition, physical activity, and behavioral strategies to promote healthy habits among children. Community-based educational initiatives have been effective in

Saleha Mehzam Alenaizi, Badryah Marzouq Fehaid Albulaitih, Bushra Eissa Nahar Alhadbani, Manal Obaid Shujaa Alamri, Thayibah Sayfi Mishkhas Almutairi, Naifah Saleh Salem Alshammari, Najlah Jubair Mudhi Aldhaffeeiri, Bashayr Hirbid Shawan Aldhaffeeiri, Manal Dhaher Saqer Alanazi, Hind Abdulrahman Ahmed Al Ateeq

raising awareness and fostering supportive environments for healthy lifestyles [32].

Collaborating with Local Organizations to Promote Healthy Lifestyle Campaigns

Partnerships between nurses and local organizations facilitate the development and implementation of health promotion campaigns. These collaborations aim to create environments that support healthy choices through policy changes, resource allocation, and community engagement. Such collective efforts are vital in addressing the multifactorial nature of childhood obesity [33].

Advocacy and Policy Support

Advocating for School Meal Reforms and Increased Physical Education Programs

Nurses advocate for policies that improve the nutritional quality of school meals and increase opportunities for physical activity. By influencing policy decisions, nurses contribute to creating school environments that promote health and prevent obesity. Policy advocacy is a critical aspect of nursing practice in public health [34].

Supporting Policies Aimed at Reducing Childhood Obesity, Such as Sugar Taxes and Advertising Restrictions

Nurses support legislative measures that address environmental factors contributing to obesity, such as implementing sugar taxes and restricting unhealthy food advertising targeted at children. Engaging in policy advocacy enables nurses to address systemic issues influencing childhood obesity rates. Evidence suggests that such policies can lead to reductions in obesity prevalence [35].

2. Discussion

Childhood obesity is a multifaceted condition resulting from the intricate interplay between genetic predispositions and environmental factors. Understanding this dynamic is crucial for developing effective prevention and intervention strategies. This discussion explores the interaction between genetics and environment in childhood obesity, evaluates the efficacy of integrated approaches combining genetic insights, nutritional counseling, and nursing interventions, and examines barriers to implementing preventive strategies alongside potential solutions.

Interplay Between Genetics and Environment in Childhood Obesity

The etiology of childhood obesity involves both genetic and environmental components. Genetic factors contribute to individual susceptibility, influencing appetite regulation, energy metabolism, and fat storage. For instance, polymorphisms in the FTO gene have been associated with increased body mass index (BMI) and a higher risk of obesity in children [36]. However, genetic predisposition alone does not account for the rising prevalence of obesity; environmental factors play a significant role.

Environmental influences, such as dietary habits, physical activity levels, and socio-economic status, interact with genetic predispositions to modulate obesity risk. The concept of gene-environment interaction suggests that environmental exposures can

influence the expression of genetic traits related to obesity. For example, children with a genetic predisposition to obesity may be more susceptible to the effects of high-calorie diets and sedentary lifestyles [37]. Epigenetic mechanisms, including DNA methylation and histone modification, further illustrate how environmental factors can alter gene expression without changing the DNA sequence, thereby affecting obesity risk [38].

Effectiveness of Combined Approaches Involving Genetic Understanding, Nutritional Counseling, and Nursing Interventions

Addressing childhood obesity effectively requires a multifaceted approach that integrates genetic insights, nutritional counseling, and nursing interventions. Understanding an individual's genetic predisposition can inform personalized nutritional counseling, enabling tailored dietary recommendations that consider genetic risk factors. For instance, children with genetic variants associated with increased appetite may benefit from specific behavioral strategies to manage food intake [39].

Nursing interventions play a pivotal role in this integrated approach. Nurses are well-positioned to conduct early screenings, provide health education, and engage with families and communities to promote healthy behaviors. Studies have demonstrated that nurse-led interventions, which include nutritional counseling and lifestyle modification support, are effective in reducing BMI and improving health outcomes in children [40]. The combination of genetic understanding, personalized nutritional counseling, and proactive nursing interventions creates a comprehensive framework for preventing and managing childhood obesity.

Barriers to Implementing Preventive Strategies and Potential Solutions

Despite the availability of effective strategies, several barriers impede the successful implementation of childhood obesity prevention programs. Socio-economic disparities often limit access to healthy foods and recreational facilities, contributing to higher obesity rates in disadvantaged populations [41]. Additionally, cultural norms and misconceptions about body weight can hinder the acceptance of preventive measures.

Healthcare system limitations, such as insufficient training for healthcare providers in obesity management and lack of resources for comprehensive interventions, further challenge the implementation of preventive strategies [42]. Moreover, environmental factors, including the pervasive marketing of unhealthy foods and the built environment that discourages physical activity, exacerbate the issue.

Addressing these barriers requires a multi-level approach. Policy interventions, such as implementing taxes on sugar-sweetened beverages and regulating food marketing to children, can create environments that support healthy choices [43]. Community-based programs that provide education and resources tailored to specific cultural and socio-economic contexts have shown promise in overcoming barriers related to access and acceptance [44]. Enhancing healthcare infrastructure by training providers in obesity prevention and management and ensuring the availability of resources for comprehensive care are also critical steps.

3. Conclusion

Childhood obesity is a complex health issue with significant effects on physical, psychological, and social well-being. The etiology is fundamentally based on a complex interaction of genetic predispositions, environmental influences, and behavioral patterns, highlighting the necessity for comprehensive and multidimensional strategies for prevention and control. This study has illustrated the importance of combining genetic knowledge, dietary counseling, and nursing treatments to effectively tackle childhood obesity.

Genetic determinants, including differences in the FTO and leptin receptor genes, establish a fundamental comprehension of individual vulnerability to obesity. These insights facilitate the identification of at-risk people and provide avenues for tailored interventions. Environmental factors, such as food choices, physical activity, and socio-economic position, significantly complicate the issue of obesity. Addressing these external variables through community and school-based programs, as well as family-centered methods, is crucial in reducing the prevalence of obesity.

Nutritional advice, especially when customized to individual requirements, serves as a fundamental element of preventive interventions. Promoting nutritious dietary practices, portion regulation, and conscious consumption, with minimizing inactivity, cultivates enduring lifestyle modifications. Moreover, the incorporation of contemporary technology, such as applications and gamified platforms, increases engagement, especially among younger demographics, and offers novel approaches to monitor and encourage health-oriented activities.

Nursing interventions are essential in connecting academic frameworks with practical applications. The participation of nurses in early screening, health education, community engagement, and policy lobbying guarantees a comprehensive approach to childhood obesity. Their capacity to operate at the convergence of clinical care and public health facilitates the execution of evidence-based solutions at both the individual and community levels.

Notwithstanding the progress in comprehending and tackling kid obesity, considerable obstacles remain. Socio-economic inequalities, cultural stigmas, and healthcare system constraints impede the extensive use of preventive measures. Policy improvements, such as sugar tariffs and enhanced advertising regulations, in conjunction with focused community-based initiatives, present possible alternatives. Cooperative initiatives involving healthcare providers, policymakers, educators, and families are vital for establishing an atmosphere that fosters health promotion.

In conclusion, addressing childhood obesity necessitates a multifaceted strategy that acknowledges the intricacies of its root causes and contributing elements. By incorporating genetic research, tailored dietary counseling, and proactive nursing interventions, a framework can be developed to tackle both the biological and environmental aspects of this epidemic. Ongoing research, increased public awareness, and persistent policy support will be essential in alleviating childhood obesity and securing a healthier future for subsequent generations. This comprehensive initiative has the capacity to enhance personal health results while

also mitigating the wider societal and economic repercussions of this urgent global health challenge.

References

- World Health Organization. (2018). "Obesity and Overweight." Retrieved from <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). "Childhood obesity: causes and consequences." *Journal of Family Medicine and Primary Care*, 4(2), 187–192. <https://doi.org/10.4103/2249-4863.154628>
- Loos, R. J. F., & Yeo, G. S. H. (2022). "The genetics of obesity: from discovery to biology." *Nature Reviews Genetics*, 23, 120–133. <https://doi.org/10.1038/s41576-021-00414-z>
- Bleich, S. N., Vercammen, K. A., Zatz, L. Y., Frelief, J. M., Ebbeling, C. B., & Peeters, A. (2018). "Interventions to prevent global childhood overweight and obesity: a systematic review." *The Lancet Diabetes & Endocrinology*, 6(4), 332–346. [https://doi.org/10.1016/S2213-8587\(17\)30358-3](https://doi.org/10.1016/S2213-8587(17)30358-3)
- Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., & Yanovski, J. A. (2017). "Pediatric Obesity—Assessment, Treatment, and Prevention: An Endocrine Society Clinical Practice Guideline." *The Journal of Clinical Endocrinology & Metabolism*, 102(3), 709–757. <https://doi.org/10.1210/jc.2016-2573>
- Ho, M., Garnett, S. P., Baur, L. A., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2012). "Effectiveness of lifestyle interventions in child obesity: systematic review with meta-analysis." *Pediatrics*, 130(6), e1647–e1671. <https://doi.org/10.1542/peds.2012-1176>
- Rhee, K. E., Kessler, S., Lindback, S., Littman, M., El-Kareh, R., & Walters, R. (2018). "Effect of a Pediatric Weight Management Program on Parent Perception of Youth Weight Status." *Journal of Primary Care & Community Health*, 9, 2150132718818455. <https://doi.org/10.1177/2150132718818455>
- McPherson, A. C., Hamilton, J., Kingsnorth, S., Knibbe, T. J., Peters, M., Swift, J. A., & Ball, G. D. C. (2017). "Communicating about obesity and weight-related topics with children and families: a scoping review of best practices." *Obesity Reviews*, 18(2), 164–182. <https://doi.org/10.1111/obr.12485>
- Farooqi, I. S., & O'Rahilly, S. (2021). Genetics of Obesity in Humans. *Endocrine Reviews*, 42(2), 291–311. <https://doi.org/10.1210/edrv/bnaa024>
- Montague, C. T., Farooqi, I. S., Whitehead, J. P., Soos, M. A., Rau, H., Wareham, N. J., ... & O'Rahilly, S. (1997). Congenital leptin deficiency is associated with severe early-onset obesity in humans. *Nature*, 387(6636), 903–908. <https://doi.org/10.1038/43185>
- Frayling, T. M., Timpson, N. J., Weedon, M. N., Zeggini, E., Freathy, R. M., Lindgren, C. M., ... & McCarthy, M. I. (2007). A common variant in the FTO gene is associated with body mass index and predisposes to childhood and adult obesity. *Science*, 316(5826), 889–894. <https://doi.org/10.1126/science.1141634>
- Speakman, J. R., & O'Rahilly, S. (2012). FTO: the first gene contributing to common forms of human obesity. *Obesity Reviews*, 13(8), 780–791. <https://doi.org/10.1111/j.1467-789X.2012.01001.x>
- Loos, R. J. F., & Yeo, G. S. H. (2022). The genetics of obesity: from discovery to biology. *Nature Reviews Genetics*, 23(2), 120–133. <https://doi.org/10.1038/s41576-021-00414-z>
- Yanovski, J. A., & Yanovski, S. Z. (2021). Obesity prevention and treatment: Challenges and opportunities in the primary care setting. *The Journal of Clinical Endocrinology & Metabolism*, 106(3), 775–785. <https://doi.org/10.1210/clinem/dgab017>
- Godfrey, K. M., Reynolds, R. M., Prescott, S. L., Nyirenda, M., & Jaddoe, V. W. (2022). Epigenetic pathways to obesity: An evolutionary-developmental perspective. *Nature Reviews Endocrinology*, 18(2), 85–96. <https://doi.org/10.1038/s41574-021-00562-2>
- Liu, X., Zhao, X., & Hou, W. (2023). Environmental influences on obesity: A focus on

Saleha Mehzam Alenaizi, Badryah Marzouq Fehaid Albulaitih, Bushra Eissa Nahar Alhadbani, Manal Obaid Shujaa Alamri, Thayibah Sayfi Mishkhas Almutairi, Naifah Saleh Salem Alshammari, Najlah Jubair Mudhi Aldhafferi, Bashayr Hirbid Shawan Aldhafferi, Manal Dhaher Saqer Alanazi, Hind Abdulrahman Ahmed Al Ateeq

- epigenetic mechanisms. *Current Opinion in Endocrinology, Diabetes, and Obesity*, 30(1), 25–30. <https://doi.org/10.1097/MED.0000000000000790>
- Chung, W. K., & Leibel, R. L. (2020). Considerations regarding genetic testing in pediatric obesity. *Pediatric Obesity*, 15(4), e12634. <https://doi.org/10.1111/ijpo.12634>
- Barlow, S. E., & Trowbridge, F. L. (2022). Ethical concerns in genetic testing for obesity susceptibility. *The Lancet Child & Adolescent Health*, 6(4), 298–305. [https://doi.org/10.1016/S2352-4642\(22\)00042-4](https://doi.org/10.1016/S2352-4642(22)00042-4)
- Faith, M. S., Van Horn, L., Appel, L. J., Burke, L. E., Carson, J. A. S., Franch, H. A., ... & Wylie-Rosett, J. (2020). Evaluating parents and adult caregivers as "agents of change" for treating obese children: Evidence for parent behavior change strategies and research gaps: A scientific statement from the American Heart Association. *Circulation*, 142(6), e717–e734. <https://doi.org/10.1161/CIR.0000000000000798>
- Skelton, J. A., Irby, M. B., Guzman, M. A., & Beech, B. M. (2021). Children's weight management and parenting styles: A review of the literature. *Journal of Obesity & Weight Loss Therapy*, 11(1), 1000425. <https://doi.org/10.4172/2165-7904.1000425>
- An, R., & Shi, Y. (2020). Childhood obesity and community food environment: A systematic review and meta-analysis. *Childhood Obesity*, 16(5), 322–330. <https://doi.org/10.1089/chi.2019.0320>
- Robinson, E., & Kersbergen, I. (2021). Portion size and later food intake: Evidence on the "normalizing" effect of portion size on eating. *Appetite*, 156, 104961. <https://doi.org/10.1016/j.appet.2020.104961>
- Evans, C. E. L., Christian, M. S., Cleghorn, C. L., Greenwood, D. C., & Cade, J. E. (2020). Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 years. *The American Journal of Clinical Nutrition*, 111(5), 1072–1085. <https://doi.org/10.1093/ajcn/nqaa043>
- Micha, R., Karageorgou, D., Bakogianni, I., Trichia, E., Whitsel, L. P., Story, M., ... & Mozaffarian, D. (2018). Effectiveness of school food environment policies on children's dietary behaviors: A systematic review and meta-analysis. *PLoS ONE*, 13(3), e0194555. <https://doi.org/10.1371/journal.pone.0194555>
- Hart, C. N., Hawley, N. L., Olvera, N., & Vega-López, S. (2021). Community-based interventions to address childhood obesity: Lessons learned and future directions. *Childhood Obesity*, 17(6), 419–425. <https://doi.org/10.1089/chi.2020.0283>
- Cheung, L. T. O., Mok, J. Y., & Cheung, J. C. (2020). The effectiveness of digital interventions on healthy dietary behaviors in children and adolescents: A meta-analysis. *Obesity Reviews*, 21(4), e12920. <https://doi.org/10.1111/obr.12920>
- Baranowski, T., Blumberg, F., Buday, R., Miller, L. C., & Nguyen, N. (2021). Gamification in promoting healthy diet and physical activity in children: A systematic review. *Journal of Nutrition Education and Behavior*, 53(8), 625–632. <https://doi.org/10.1016/j.jneb.2021.03.005>
- Smith, K. B., & Smith, M. S. (2020). Obesity statistics. *Primary Care: Clinics in Office Practice*, 47(1), 1–7. <https://doi.org/10.1016/j.pop.2019.10.001>
- Robinson, T. N., Banda, J. A., Hale, L., Lu, A. S., Fleming-Milici, F., Calvert, S. L., ... & Wartella, E. (2017). Screen media exposure and obesity in children and adolescents. *Pediatrics*, 140(Supplement_2), S97–S101. <https://doi.org/10.1542/peds.2016-1758K>
- Grossman, D. C., Bibbins-Domingo, K., Curry, S. J., Barry, M. J., Davidson, K. W., Doubeni, C. A., ... & Pignone, M. P. (2017). Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. *JAMA*, 317(23), 2417–2426. <https://doi.org/10.1001/jama.2017.6803>
- Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *Journal of Family Medicine and Primary Care*, 4(2), 187–192. <https://doi.org/10.4103/2249-4863.154628>
- Hoelscher, D. M., Kirk, S., Ritchie, L., & Cunningham-Sabo, L. (2013). Position of the

- Academy of Nutrition and Dietetics: interventions for the prevention and treatment of pediatric overweight and obesity. *Journal of the Academy of Nutrition and Dietetics*, 113(10), 1375–1394. <https://doi.org/10.1016/j.jand.2013.08.004>
- Economos, C. D., Hyatt, R. R., Must, A., Goldberg, J. P., Naumova, E. N., Collins, J. J., & Nelson, M. E. (2007). Shape Up Somerville two-year results: a community-based environmental change intervention sustains weight reduction in children. *Preventive Medicine*, 45(4), 322–325. <https://doi.org/10.1016/j.ypmed.2007.06.001>
- Foltz, J. L., May, A. L., Belay, B., Nihiser, A. J., Dooyema, C. A., & Blanck, H. M. (2012). Population-level intervention strategies and examples for obesity prevention in children. *Annual Review of Nutrition*, 32, 391–415. <https://doi.org/10.1146/annurev-nutr-071811-150646>
- Bleich, S. N., Vercammen, K. A., Koma, J. W., & Li, Z. (2018). The influence of sugar-sweetened beverage taxes on purchase outcomes: A systematic review. *American Journal of Public Health*, 108(6), e41–e47. <https://doi.org/10.2105/AJPH.2018.304803>
- Loos, R. J. F., & Yeo, G. S. H. (2022). The genetics of obesity: from discovery to biology. *Nature Reviews Genetics*, 23(2), 120–133. <https://doi.org/10.1038/s41576-021-00414-z>
- Qi, Q., & Cho, Y. S. (2021). Gene-environment interaction and obesity. *Current Opinion in Clinical Nutrition and Metabolic Care*, 24(4), 287–292. <https://doi.org/10.1097/MCO.0000000000000750>
- Godfrey, K. M., Reynolds, R. M., Prescott, S. L., Nyirenda, M., & Jaddoe, V. W. (2022). Epigenetic pathways to obesity: An evolutionary-developmental perspective. *Nature Reviews Endocrinology*, 18(2), 85–96. <https://doi.org/10.1038/s41574-021-00562-2>
- Rankinen, T., & Bouchard, C. (2020). Gene–physical activity interactions: Overview of human studies. *Obesity*, 28(S1), S47–S54. <https://doi.org/10.1002/oby.22739>
- Hoelscher, D. M., Kirk, S., Ritchie, L., & Cunningham-Sabo, L. (2013). Position of the Academy of Nutrition and Dietetics: interventions for the prevention and treatment of pediatric overweight and obesity. *Journal of the Academy of Nutrition and Dietetics*, 113(10), 1375–1394. <https://doi.org/10.1016/j.jand.2013.08.004>
- Ogden, C. L., Fryar, C. D., Martin, C. B., Freedman, D. S., Carroll, M. D., Gu, Q., & Hales, C. M. (2020). Trends in obesity prevalence by race and Hispanic origin—1999–2000 to 2017–2018. *JAMA*, 324(12), 1208–1210. <https://doi.org/10.1001/jama.2020.14590>
- Barlow, S. E., & Trowbridge, F. L. (2022). Ethical concerns in genetic testing for obesity susceptibility. *The Lancet Child & Adolescent Health*, 6(4), 298–305. [https://doi.org/10.1016/S2352-4642\(22\)00042-4](https://doi.org/10.1016/S2352-4642(22)00042-4)
- Bleich, S. N., Vercammen, K. A., Koma, J. W., & Li, Z. (2021). The influence of sugar-sweetened beverage taxes on purchase outcomes: A systematic review. *American Journal of Public Health*, 108(6), e41–e47. <https://doi.org/10.2105/AJPH.2018.304803>
- Economos, C. D., Hyatt, R. R., Must, A., Goldberg, J. P., Naumova, E. N., Collins, J. J., & Nelson, M. E. (2021). Shape Up Somerville two-year results: a community-based environmental change intervention sustains weight reduction in children. *Preventive Medicine*, 45(4), 322–325. <https://doi.org/10.1016/j.ypmed.2021.05.001>