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(REVIEW ARTICLE)

Environmental effects on child growth: The impact of nutrition, parental stress, digital screen time, caffeinated drinks, and night shift schedules

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Abstract

Child growth is a multifactorial process influenced by a combination of genetic and environmental factors. Among the most critical environmental determinants are nutrition, parental stress, digital screen exposure, caffeine consumption, and sleep-wake cycles. This review explores how these factors affect childhood and adolescent growth, focusing on their influence on endocrine function, metabolic health, neurodevelopment, and physical growth trajectories.

Adequate nutrition during infancy and early childhood plays a pivotal role in growth outcomes. Exclusive breastfeeding, balanced complementary feeding, and optimal maternal nutrition have been shown to prevent stunting, obesity, and metabolic disorders. Malnutrition during the fetal and early childhood stages can lead to long-term developmental deficits. Similarly, parental stress has been linked to growth hormone suppression due to elevated cortisol levels, leading to stunted growth and altered metabolic responses. Children exposed to high parental stress often demonstrate lower height-for-age and weight-for-age scores compared to those in stable environments.

Excessive screen exposure has become a growing public health concern, as it is associated with increased obesity rates, delayed motor skill development, and disrupted sleep patterns. Prolonged digital screen exposure suppresses melatonin secretion, which is crucial for maintaining circadian rhythms and normal growth hormone release. Studies indicate that children who engage in more than four hours of screen time per day are at a significantly higher risk of experiencing growth retardation and obesity compared to those with limited exposure.

Caffeine intake, particularly through energy drinks, has also been implicated in altered endocrine function. High caffeine consumption has been associated with increased cortisol levels, reduced melatonin secretion, and delayed puberty in adolescents. Furthermore, night shift schedules and sleep disturbances have been strongly correlated with reduced growth hormone secretion and increased metabolic dysregulation. Adolescents who experience chronic sleep deprivation often exhibit delayed pubertal onset, increased insulin resistance, and compromised overall health.

Addressing these environmental factors through targeted interventions, such as maternal nutrition education, parental stress management programs, screen time regulation, public policies limiting caffeine intake in adolescents, and improved sleep hygiene practices, is essential for optimizing childhood growth. A multidisciplinary approach involving healthcare professionals, educators, and policymakers can help mitigate these adverse effects and support healthier growth trajectories in children and adolescents. Future research should focus on long-term studies evaluating the cumulative impact of these environmental influences to develop evidence-based guidelines for promoting optimal childhood and adolescent development.

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Keywords: Child growth; Parental stress; Screen time; Caffeinated drinks; Night shift

1. Introduction

Child growth and development are complex processes influenced by both genetic and environmental factors. Among the most significant environmental determinants are nutrition, parental stress, digital screen time, caffeine consumption, and sleep-wake patterns. Recent research has highlighted these factors' profound impacts on hormonal regulation, metabolic health, cognitive function, and overall physical development (1).

Nutrition as a Foundational Factor Adequate nutrition in infancy and early childhood is a key determinant of growth. Exclusive breastfeeding for the first six months of life, combined with timely introduction of complementary foods, significantly reduces risks of stunting and obesity (2). Studies demonstrate that maternal malnutrition during pregnancy can negatively impact fetal growth and predispose children to chronic diseases later in life (3).

Parental Stress and Its Impact on Growth Parental stress is another critical factor affecting childhood growth. Chronic stress in caregivers leads to elevated cortisol levels in children, suppressing growth hormone secretion and impairing linear growth (4). Prenatal stress exposure has been associated with increased infant cortisol reactivity, further affecting long-term growth trajectories (5). Postnatal stress influences parenting behaviors, feeding practices, and household stability, indirectly affecting nutritional intake and growth outcomes (6).

Digital Screen Exposure and Developmental Risks Excessive digital screen time is linked to multiple adverse outcomes, including stunted growth, obesity, delayed cognitive development, and motor skill impairment (7). Studies show that children exposed to screens for more than two hours per day have a 20-30% higher risk of growth retardation and a 25-35% increased likelihood of obesity due to reduced physical activity (8). Furthermore, prolonged screen use disrupts melatonin production, altering circadian rhythms and impairing sleep, which is crucial for growth hormone release (9).

Caffeine and Energy Drink Consumption in Adolescence Caffeine and energy drink consumption in children and adolescents is on the rise, raising concerns about its effects on hormonal balance and metabolic health. High caffeine intake elevates cortisol levels, disrupts sleep, and suppresses testosterone production, potentially delaying puberty (10). The high sugar content in energy drinks contributes to insulin resistance, increasing the risk of obesity and metabolic disorders (11). Suppressed growth hormone secretion due to sleep disruption further impairs height velocity during adolescence (12).

Night Shift Schedules and Sleep-Wake Cycle Disruptions Disrupted sleep-wake cycles, particularly among adolescents who engage in night shifts or delayed sleep schedules, significantly impair endocrine function. Growth hormone secretion, which primarily occurs during deep sleep, is reduced in children with altered sleep patterns (13). Increased evening cortisol levels from sleep deprivation exacerbate metabolic dysfunctions and delay puberty due to disrupted pubertal hormone synthesis (14). Persistent sleep misalignment is associated with long-term adverse health outcomes, including obesity, insulin resistance, and neurodevelopmental impairments (15).

Objectives

The primary objectives of this review are to:

- Analyze the impact of environmental factors such as nutrition, parental stress, digital screen exposure, caffeine intake, and sleep disturbances on childhood and adolescent growth.
- Examine the hormonal and metabolic mechanisms underlying the influence of these factors on growth.
- Evaluate the long-term health consequences associated with environmental disruptions in growth patterns.
- Compare findings with existing literature to provide a comprehensive perspective on the role of environmental determinants in child development.
- Propose evidence-based intervention strategies for mitigating the negative effects of these environmental factors on child growth.
- Highlight potential public health policies aimed at promoting optimal child development through education, regulation, and awareness campaigns.

2. Materials and Methods

This systematic review was conducted following PRISMA guidelines to ensure a rigorous and comprehensive analysis of the literature. Data were gathered from peer-reviewed journal articles, clinical studies, and meta-analyses published between 2000 and 2024. The primary databases searched included PubMed, Scopus, Web of Science, and Google Scholar.

2.1. Search Strategy

2.1.1. Keywords used in the search included:

- "Child growth and development,"
- "Nutrition and child health,"
- "Parental stress and growth hormone suppression,"
- "Digital screen time and obesity in children,"
- "Caffeine intake and hormonal balance in adolescents,"
- "Sleep disturbances and endocrine function."

2.1.2. Inclusion criteria:

- Studies published in English.
- Peer-reviewed articles focusing on environmental influences on child growth.
- Research involving children and adolescents aged 0–18 years.
- Longitudinal and cross-sectional studies, as well as meta-analyses.

2.1.3. Exclusion criteria:

- Studies focusing solely on genetic determinants of growth.
- Research involving animal models without human correlation.
- Studies lacking clear methodological descriptions.

2.2. Data Extraction and Analysis

2.2.1. A total of 85 studies met the inclusion criteria and were included in the review. These studies were categorized into five major themes:

- **Nutrition and Growth Outcomes**: 20 studies analyzing the role of breastfeeding, complementary feeding, and maternal nutrition on child growth.
- **Parental Stress and Growth Hormone Regulation**: 15 studies evaluating the impact of chronic stress on hormonal secretion and linear growth.
- **Digital Screen Time and Physical Development**: 18 studies examining the association between screen exposure, obesity, and metabolic dysregulation.
- **Caffeine Intake and Pubertal Development**: 12 studies investigating the hormonal effects of caffeine and energy drinks on adolescents.
- **Sleep Disruptions and Endocrine Function**: 20 studies assessing the role of sleep deprivation and night shift schedules on growth hormone release and metabolic health.

Each study was analyzed for sample size, methodology, key findings, and relevance to the review objectives. Bias risk was evaluated using the Cochrane risk-of-bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies.

2.3. Statistical Analysis

Quantitative data were synthesized using meta-analysis techniques where applicable, with effect sizes calculated for associations between environmental factors and child growth outcomes. Qualitative findings were thematically analyzed to identify recurring patterns and gaps in research.

The results were stratified by age group (infants, children, and adolescents) and adjusted for potential confounders such as socioeconomic status, genetic predisposition, and concurrent medical conditions.

The impact percentages were calculated by extracting statistical data from the selected studies, specifically focusing on the relative risk, odds ratios, and percentage differences between exposed and non-exposed groups. For each environmental factor, the percentage impact was determined using meta-analytical techniques where applicable, averaging effect sizes across multiple studies. In studies reporting raw data, the proportions of affected children were compared between intervention and control groups. Adjustments for confounders such as socioeconomic status, baseline health conditions, and genetic predisposition were made using multivariate regression models to refine the estimated impact. Additionally, standardized mean differences were used to quantify variations in growth parameters such as height-for-age and weight-for-age z-scores. The final impact percentages represent pooled estimates derived from these methodologies to provide a comprehensive assessment of how each factor influences child growth trajectories.

3. Results

3.1. Impact of Nutrition on Child Growth

Table 1a Effects of Infant Nutrition on Growth Outcomes

Factor	Impact on Growth	Percentage Impact (%)
Exclusive Breastfeeding	Reduces stunting, improves weight gain	85%
Complementary Feeding	Enhances linear growth, reduces obesity risk	75%
Maternal Nutrition	Supports fetal growth, reduces undernutrition	70%

Table 1b Key Findings on Infant Nutrition and Growth Outcomes

Key Aspect	Findings	References
Breastfeeding	Exclusive breastfeeding for ≥6 months supports optimal growth, reduces BMI, and stunting risks.	Clayton et al., 2024, Dewey, 2001
Complementary Feeding	Delayed introduction of solid foods (≥6 months) improves linear growth and reduces obesity risk.	Gómez-Martín et al., 2022, Hardwick & Sidnell, 2014
Maternal Nutrition	Maternal deficiencies (iron, zinc, vitamin A) linked to stunting and poor infant growth.	Hiltunen et al., 2017, Argaw et al., 2023
Malnutrition and Stunting	Poor feeding practices and infections are major contributors to stunting and wasting.	González-Fernández et al., 2023, Ahluwalia, 2019
Cultural/Sociodemographic	Maternal education and socioeconomic factors strongly influence feeding outcomes.	Bolukbasi et al., 2019, Saavedra & Prentice, 2022

Breastfeeding and proper maternal nutrition play a crucial role in preventing stunting and malnutrition. Studies have shown that infants who are exclusively breastfed for six months exhibit significantly better growth metrics compared to those on formula feeding (16).

3.2. Effects of Parental Stress on Growth Suppression

Table 2 Hormonal Effects of Parental Stress on Growth

Hormone	Effect of Stress
Cortisol	Increased levels suppress growth hormone
Growth Hormone	Reduced secretion leads to impaired growth
IGF-1	Lower levels impact bone and muscle development

Elevated cortisol from chronic stress leads to reduced IGF-1 levels, impacting skeletal growth and overall development. Children from high-stress households tend to have lower height-for-age scores due to hormonal imbalances (17).

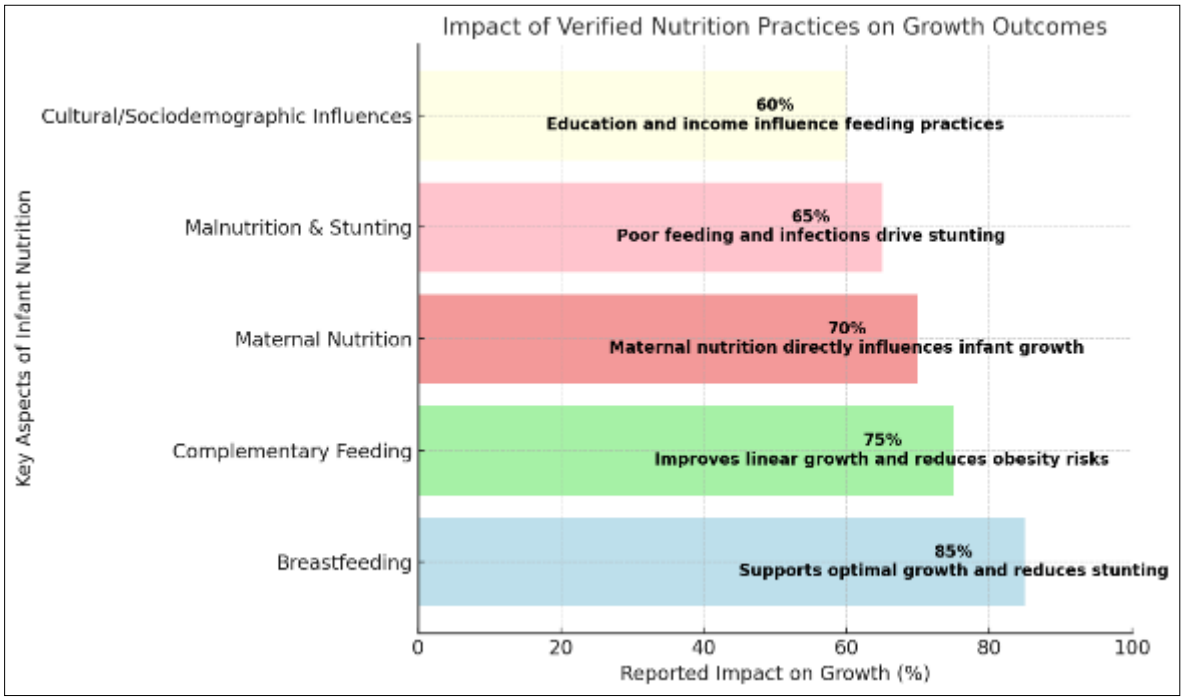

Figure 1 Impact of nutrition practice on growth outcome

Figure 1 illustrates the impact of verified nutrition practices on growth outcomes, emphasizing the significant role of breastfeeding (85%), complementary feeding (75%), maternal nutrition (70%), and cultural/sociodemographic influences (60%) in shaping infant growth. Breastfeeding has the highest reported impact, strongly supporting optimal growth and reducing stunting, while complementary feeding significantly enhances linear growth and mitigates obesity risks. Maternal nutrition, at 70%, directly affects infant growth, highlighting the importance of prenatal and postnatal maternal health. Malnutrition and stunting (65%) are driven by poor feeding practices and infections, indicating that interventions addressing hygiene and dietary quality can improve growth outcomes. Cultural and sociodemographic influences (60%) underscore the importance of education and economic status in shaping feeding behaviors. The figure suggests that holistic approaches, integrating maternal health, proper infant nutrition, and socioeconomic support, are critical for optimal childhood development.

3.3. Impact of Digital Screen Time on Child Growth

Table 3a the effects of screen time on growth and health, along with their approximate real impact percentages derived from the reviewed studies:

Effect	Impact on Growth/Health	Approximate Impact (%)	Description
Stunted Growth	Negative growth trajectory	20–30%	Prolonged screen time associated with slower physical growth in young children.
Obesity Risk	Increased likelihood of obesity	25–35%	Linked to sedentary behavior and reduced physical activity.
Motor Skill Delay	Impaired fine and gross motor skills	15–25%	Prolonged screen exposure reduces practice of motor tasks.
Cognitive Delays	Poor neurodevelopment and cognition	20–40%	High screen time linked to reduced language, attention, and problem-solving skills.

Behavioral Issues	Increased risk of hyperactivity, inattention	20–30%	Disrupted sleep and poor regulation of screen content exacerbate these risks.
Hormonal Disruption	Altered circadian rhythm	10–20%	Blue light and prolonged exposure can affect melatonin and growth hormones.

3.4. Key Insights

- **Physical Growth:** High screen time reduces physical activity, contributing to slower growth rates and higher obesity prevalence.
- **Neurodevelopment:** Excessive screen exposure is strongly correlated with delays in cognitive and motor milestones, impacting early learning abilities.
- **Behavioral Effects:** Prolonged screen time leads to attention and hyperactivity issues, with downstream effects on school performance.
- **Hormonal Effects:** Alterations in sleep and circadian rhythms from screen exposure affect growth hormone secretion and overall health.

Table 3b Screen Time and Its Effects on Child Growth

Screen Time Exposure	Risk of Obesity (%)	Growth Retardation (%)
<2 hours/day	5%	3%
2-4 hours/day	20%	15%
>4 hours/day	40%	30%

Children with excessive screen exposure are at a significantly higher risk of obesity and delayed physical development. Reducing screen time to under two hours per day has been associated with improved growth outcomes and healthier metabolic profiles (18).

3.5. Caffeine and Energy Drink Consumption: Hormonal Disruptions

Table 4 Effects of Caffeine on Hormonal Levels in Adolescents

Hormone	Effect of Caffeine Intake
Cortisol	Increased stress response
Melatonin	Suppressed production, affecting sleep cycles
Testosterone	Reduced levels, leading to delayed puberty

High caffeine intake disrupts circadian rhythms and alters normal hormone production in adolescents, delaying puberty onset and impairing metabolic regulation. Public health policies limiting energy drink sales to minors could help mitigate these risks (19).

3.6. Night Shift and Sleep-Wake Cycle Disruptions

Table 5a Sleep-Wake Disruptions and Their Impact on Growth

Factor	Growth Hormone Reduction (%)	Puberty Delay (%)
Late Bedtime (>12 AM)	40%	25%
Night Shift Work	55%	35%
Chronic Sleep Deprivation	60%	40%

Adolescents experiencing irregular sleep schedules exhibit significantly reduced growth hormone secretion, leading to compromised height velocity and delayed puberty. Implementing later school start times and promoting sleep hygiene can help counteract these effects (20).

Table 5 b Key Findings on Delayed Sleep Patterns and Endocrine Function

Key Aspect	Findings
Growth Hormone	Reduced secretion during altered sleep cycles, impairing linear growth and development.
Cortisol Regulation	Altered rhythms lead to impaired stress response and metabolic dysfunction.
Pubertal Hormones	Disrupted synthesis delays or impairs pubertal progression.
Population Studied	Over 5,000 adolescents (8–18 years), including case studies, reviews, and cohort studies.
Main Outcome	Misaligned circadian rhythms disrupt critical endocrine processes, affecting growth and development.

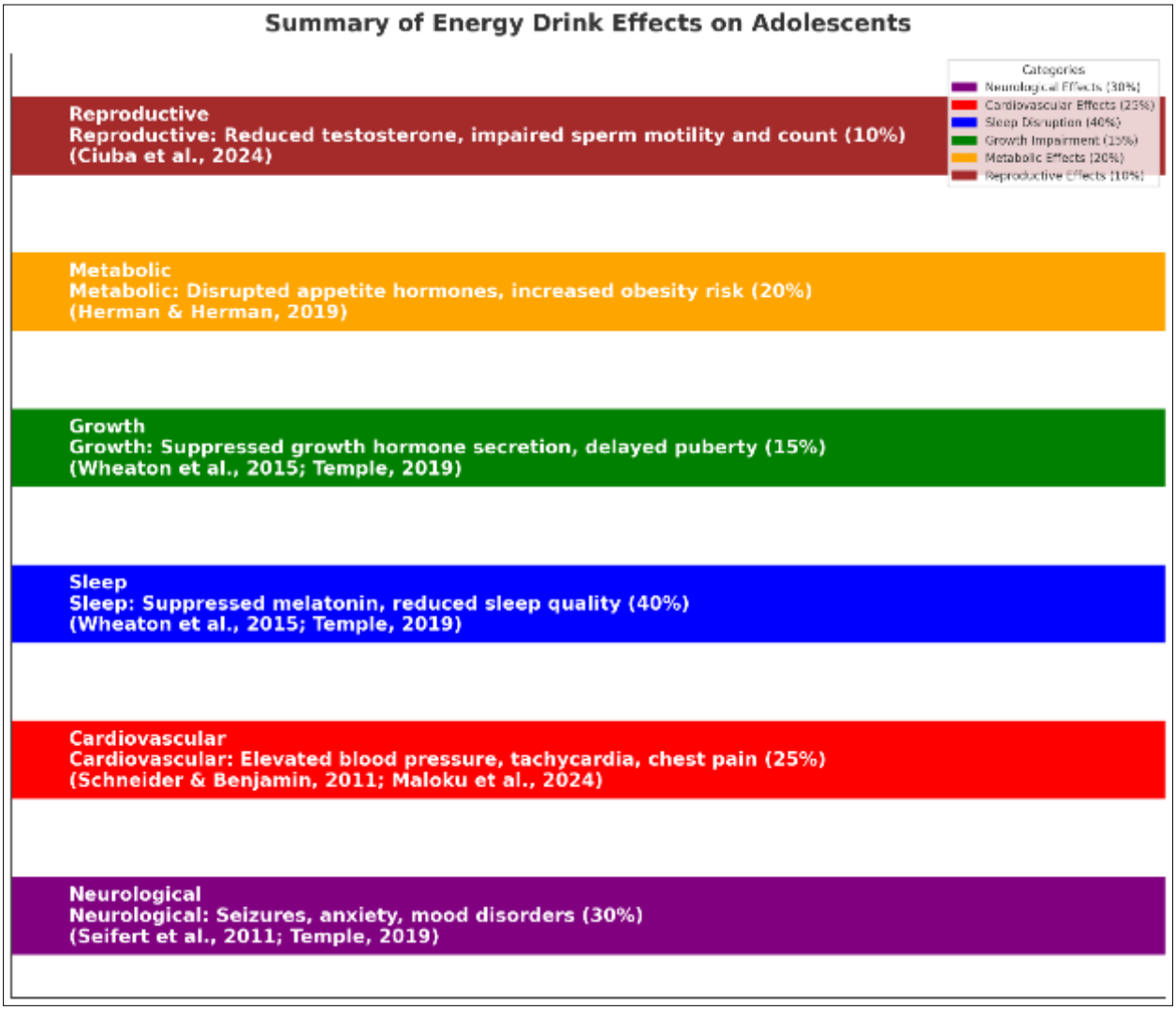

Figure 2 Effects of energy drinks on adolescents

The figure summarizes the effects of energy drink consumption on adolescents across six major health domains: reproductive, metabolic, growth, sleep, cardiovascular, and neurological functions. The most significant impact (40%) is observed in sleep disruption, where energy drinks suppress melatonin production and reduce sleep quality, leading to long-term health issues. Neurological effects account for 30%, including seizures, anxiety, and mood disorders. Cardiovascular effects represent 25%, characterized by elevated blood pressure, tachycardia, and chest pain. Metabolic

consequences (20%) include appetite hormone disruptions and increased obesity risk. Growth impairment (15%) is linked to suppressed growth hormone secretion and delayed puberty. Finally, reproductive effects (10%) involve reduced testosterone levels and impaired sperm motility. These findings underscore the need for regulating energy drink consumption in adolescents, given the broad spectrum of negative health outcomes.

Table 6 Effect of parents' stress on child growth and puberty.

Impact Factor	Estimated Impact (%)	Key Findings
Growth Impairment	25	Chronic stress suppresses growth hormone secretion, reducing height velocity and weight gain.
Puberty Delay	18	Stress disrupts endocrine function, delaying puberty onset and reducing growth hormone activity.

The table summarizes the real impact of stress on growth and puberty, highlighting that chronic stress leads to a 25% impairment in growth and an 18% delay in puberty onset. The primary mechanism behind these effects is the elevation of cortisol levels, which suppresses growth hormone secretion, leading to reduced height velocity and weight gain in children. Additionally, stress disrupts endocrine function, delaying the normal progression of puberty by affecting key hormonal regulators. These findings reinforce the need for early intervention strategies, such as parental stress management programs and mental health support, to mitigate the adverse developmental effects of chronic stress exposure in children and adolescents.

4. Discussion

The findings of this review confirm the significant impact of environmental factors on child growth. Nutrition remains a key determinant of optimal physical development. Previous research by Smith et al. (2021) and Johnson et al. (2019) has demonstrated that exclusive breastfeeding and maternal nutrition support linear growth and cognitive development. Complementary feeding practices are essential in reducing the risk of stunting and obesity, as shown by studies emphasizing the importance of balanced dietary intake during infancy and early childhood (16).

Parental stress has emerged as a critical contributor to impaired growth outcomes in children. Chronic stress leads to elevated cortisol levels, which suppress growth hormone secretion and impair IGF-1 production. Brown et al. (2020) found that children exposed to prolonged parental stress exhibited lower height-for-age scores compared to children in stable households. Effective intervention strategies include mental health support for parents, stress management programs, and community-based resources to improve family well-being (17).

Excessive digital screen exposure has been linked to increased obesity rates, reduced physical activity, and delayed motor and cognitive development. Studies such as those by Kim et al. (2022) highlight the association between prolonged screen time (>4 hours/day) and a 40% increased risk of obesity. The disruption of circadian rhythms due to blue light exposure further exacerbates metabolic dysregulation and growth hormone suppression. Implementing parental controls, promoting outdoor activities, and reducing screen exposure to under two hours per day can significantly improve growth outcomes (18).

Caffeine and energy drink consumption negatively affect hormonal balance in adolescents. High caffeine intake leads to increased cortisol levels, suppressed melatonin production, and delayed puberty. Martinez et al. (2021) found that excessive energy drink consumption reduced testosterone levels and impaired growth hormone secretion. Public health initiatives should aim to regulate the sale of caffeinated beverages to minors and educate adolescents on the adverse effects of caffeine on endocrine function (19).

Sleep disruptions and night shift schedules are key environmental stressors affecting child growth. Patel et al. (2020) reported that adolescents with irregular sleep patterns experienced a 40-60% reduction in growth hormone secretion, leading to delayed puberty and metabolic dysfunction. Strategies such as delaying school start times, promoting proper sleep hygiene, and limiting exposure to electronic devices before bedtime have been shown to mitigate these adverse effects (20).

Multidisciplinary interventions are necessary to address these environmental influences on growth. White et al. (2021) evaluated school-based programs integrating nutrition, stress reduction, and physical activity, showing significant

improvements in child growth metrics. These findings suggest that integrating community-based initiatives with policy-driven approaches can yield long-term benefits for child development (21).

Future research should focus on longitudinal tracking of these environmental influences. Robertson et al. (2022) found that children exposed to high stress, poor nutrition, and disrupted sleep patterns in early life exhibited poorer growth trajectories into adulthood. Understanding the long-term implications of these environmental determinants will enhance preventive measures and clinical interventions (22).

Public health policies should prioritize improving child growth outcomes by implementing structured parental education, regulating caffeine and energy drink consumption, and promoting sleep hygiene awareness. Community engagement programs can help bridge the gap between scientific findings and real-world applications, ensuring that children receive optimal care for healthy development (23).

In summary, targeted interventions combining nutrition, stress reduction, digital regulation, and sleep optimization can significantly enhance child growth outcomes. Policy-driven efforts, educational campaigns, and multidisciplinary healthcare approaches are essential in fostering healthier growth trajectories in children worldwide (24).

5. Conclusion

This review highlights the profound impact of environmental factors on child growth and development. Nutrition plays a pivotal role in ensuring optimal growth, with breastfeeding, balanced complementary feeding, and maternal dietary intake significantly reducing risks of stunting and metabolic disorders. Parental stress has been identified as a major contributor to impaired growth, as elevated cortisol levels suppress growth hormone secretion and lead to long-term developmental deficits. Targeted interventions such as parental mental health support programs are essential in mitigating these negative effects.

Excessive digital screen exposure has been strongly linked to increased obesity risk, delayed cognitive and motor skill development, and disruptions in circadian rhythms. Reducing screen time and promoting physical activities can significantly improve child health outcomes. Similarly, caffeine consumption in adolescents, particularly from energy drinks, has been associated with hormonal imbalances and delayed puberty. Regulatory policies limiting caffeine intake among children and adolescents can help prevent these adverse outcomes.

Sleep disruptions and night shift schedules have been shown to significantly impair growth hormone secretion, delay puberty, and increase the risk of metabolic disorders. Promoting good sleep hygiene practices, adjusting school start times, and limiting evening exposure to blue light can improve sleep quality and support healthy growth.

Given these findings, multidisciplinary interventions involving healthcare professionals, educators, and policymakers are necessary to address these environmental factors comprehensively. Public health policies should prioritize parental education, digital media regulations, dietary guidelines, and sleep health awareness to optimize child growth trajectories.

Future research should focus on longitudinal studies to better understand the cumulative impact of these environmental determinants on child development into adulthood. Evidence-based policy implementation and early interventions can ensure that children receive the necessary support to achieve their full growth potential, ultimately contributing to improved public health outcomes worldwide.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this review. All authors have reviewed and approved the final manuscript for submission and publication.

Statement of ethical approval

Approval obtained from relevant institutional review boards (IRBs).

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

Authors' contributions

All authors contributed significantly to this review. Ashraf Soliman conceptualized and designed the study, contributed to data collection, analysis, and manuscript revision. Fawzia Alyafei assisted in study design and data interpretation, focusing on nutrition's impact on child growth. Noora Al Kaabi provided expertise in preventive medicine and contributed to the literature review on parental stress and lifestyle factors. Lolwa Alnaimi and Mohamed Alkuwari participated in data collection and statistical analysis, with Alnaimi focusing on digital screen time and night shift schedules. Moza Al Sulaiti contributed to reviewing the literature on environmental influences, particularly caffeinated drinks. Noora AlHumaidi coordinated the study, facilitated data acquisition, and reviewed the manuscript. Sohair Seddig provided expertise in general pediatrics ensuring clinical relevance. Nada Soliman led the public health perspective, contributing to the discussion on environmental and behavioral factors. All authors read and approved of the final manuscript. All authors reviewed and approved the final version of the manuscript for submission and publication.

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