

The Impact of Nutrition on Academic Performance: A Review of Evidence and Implications for Student Education

Dr. Sonam Bansal

Assistant professor, Rao Lal Singh College of education Sidhrawali Gurgaon Haryana

sonambansal9099@gmail.com

Abstract. This paper provides a comprehensive review of existing evidence regarding the impact of nutrition on academic performance among students. The relationship between nutrition and cognitive function has been extensively studied, and findings suggest that diet quality significantly influences various aspects of academic achievement, including cognitive abilities, concentration, memory, and overall academic performance. Moreover, nutritional deficiencies have been linked to impaired cognitive development and academic outcomes. This paper examines the key nutrients essential for optimal brain function and explores how dietary patterns affect academic performance. Additionally, it discusses the role of school-based nutrition programs and interventions in improving students' nutritional status and educational outcomes. Understanding the intricate link between nutrition and academic performance is crucial for educators, policymakers, and healthcare professionals to develop effective strategies that promote students' well-being and academic success.

Keywords: nutrition, academic performance, cognitive function, dietary patterns, school-based interventions

I. Introduction

In the pursuit of academic excellence, educators, policymakers, and parents often emphasize various factors such as rigorous curricula, effective teaching methods, and access to educational resources. However, one aspect that is sometimes overlooked but holds significant importance is nutrition [1]. The link between nutrition and academic performance has garnered increasing attention in recent years, with research highlighting the profound impact of dietary habits on students' cognitive function, concentration, and overall academic achievement [2]. As such, understanding the intricate relationship between nutrition and academic performance is essential for optimizing student learning outcomes and promoting holistic well-being. Nutrition plays a pivotal role in supporting optimal brain function and cognitive development, particularly during childhood and adolescence, critical periods of growth and learning. The brain is a metabolically active organ that requires a constant supply of nutrients to function efficiently [3]. Essential nutrients such as vitamins, minerals, proteins, carbohydrates, and fats are fundamental for various neurological processes, including neurotransmitter synthesis, neuronal signaling, and synaptic plasticity [4]. Consequently, inadequate intake of these nutrients can compromise cognitive abilities and academic performance.

The significance of nutrition in education is underscored by the growing prevalence of poor dietary habits and nutritional deficiencies among students, exacerbated by factors such as socioeconomic disparities, limited access to healthy foods, and the pervasive influence of processed and convenience foods. Research indicates that many students consume diets high in refined sugars, saturated fats, and processed foods, while lacking essential nutrients vital for brain health and academic success [5]. Moreover, lifestyle factors such as irregular meal

patterns, skipping breakfast, and inadequate hydration further contribute to suboptimal cognitive function and diminished academic performance.



Figure 1. Nutrition and Academic Performance

This review aims to examine the existing evidence regarding the impact of nutrition on academic performance and elucidate the implications for student education. By synthesizing findings from diverse research studies, this paper seeks to provide a comprehensive understanding of how dietary patterns and nutritional status influence cognitive function, learning outcomes, and overall academic success among students [6]. Furthermore, it aims to highlight the role of school-based nutrition programs and interventions in addressing

nutritional deficiencies and promoting positive health behaviors conducive to academic achievement.

Through a thorough analysis of the literature, this review will explore the following key aspects:

- The relationship between nutrition and cognitive function, elucidating the mechanisms by which dietary factors influence brain health and academic performance.
- The evidence linking specific nutrients and dietary patterns to academic achievement, examining how nutritional deficiencies impact learning outcomes.
- The role of school-based nutrition programs and interventions in improving students' nutritional status and educational attainment.

The implications of these findings for educators, policymakers, and healthcare professionals, emphasizing the importance of integrating nutrition education into educational practices and policies.

II. Nutrition and Cognitive Function

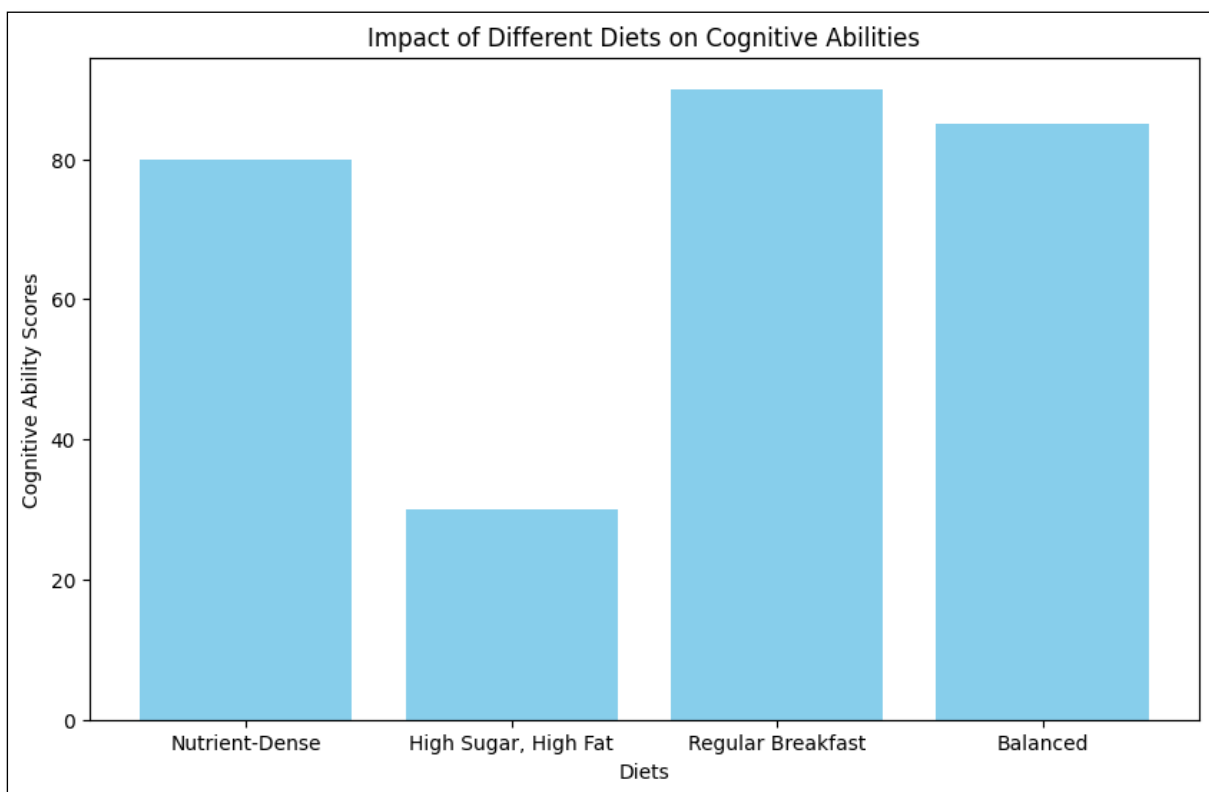


Figure 2. Impact of Different Diets on Cognitive Abilities

A. Key Nutrients for Brain Health

Essential nutrients play a crucial role in supporting optimal brain function and cognitive performance. Among these, omega-3 fatty acids, particularly docosahexaenoic acid (DHA), are essential for neuronal membrane integrity and synaptic function, thereby facilitating learning and memory processes. Additionally, vitamins such as B vitamins (e.g., folate, vitamin

B12) and antioxidants (e.g., vitamin C, vitamin E) contribute to neuroprotection and neurotransmitter synthesis [7], essential for cognitive function. Minerals like iron, zinc, and magnesium are also vital for neuronal signaling, synaptic plasticity, and energy metabolism in the brain.

Nutrient	Function	Food Sources
Omega-3 fatty acids (DHA)	Essential for neuronal membrane integrity and synaptic function	Fatty fish (salmon, mackerel), flaxseeds, walnuts
B Vitamins (folate, vitamin B12)	Neural tube development, myelination, neurotransmitter synthesis	Leafy greens, legumes, fortified cereals, animal products (meat, fish, dairy)
Antioxidants (vitamin C, vitamin E)	Protect against oxidative stress, preserve cognitive function	Citrus fruits, berries, nuts, seeds, vegetable oils
Iron, Zinc, Magnesium	Neuronal signaling, synaptic plasticity, energy metabolism	Lean meats, seafood, nuts, seeds, whole grains, legumes

Table 1: Key Nutrients for Brain Health

B. Impact of Diet on Cognitive Abilities

Dietary **patterns** can significantly influence cognitive abilities, including attention, memory, and executive functions. Research suggests that diets rich in fruits, vegetables, whole grains, and lean proteins are associated with better cognitive performance [8], whereas diets high in refined sugars, saturated fats, and processed foods may impair cognitive function. Regular consumption of nutrient-dense foods provides the necessary substrates for neurotransmitter synthesis, promotes neurogenesis, and enhances synaptic plasticity, facilitating optimal cognitive function and academic performance.

Dietary Factor	Impact on Cognitive Abilities
Nutrient-Dense Diet	Improves attention, memory, and executive function
High Sugar, High Fat Diet	Impairs cognitive function, attention, and memory
Regular Breakfast Consumption	Enhances cognitive performance, attention, and classroom behavior
Balanced Diet	Promotes optimal cognitive function, concentration, and learning outcomes

Table 2: Impact of Diet on Cognitive Abilities

C. Mechanisms Underlying the Relationship between Nutrition and Cognitive Function

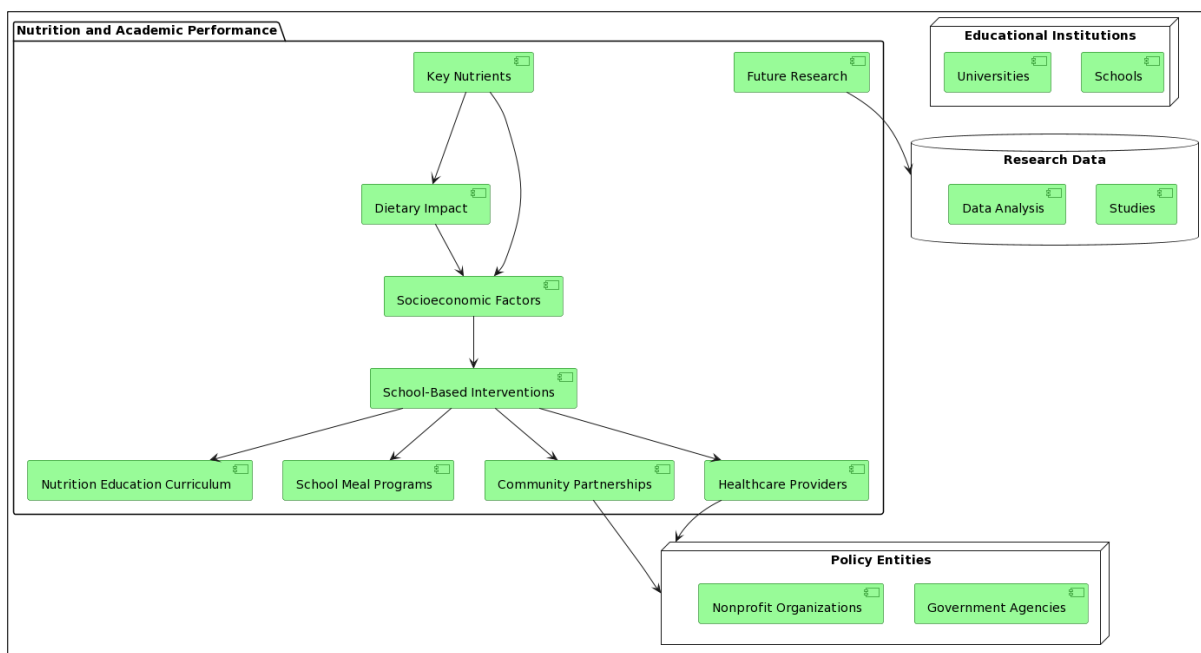


Figure 3. Mechanisms Underlying the Relationship between Nutrition and Cognitive Function

The relationship between nutrition and cognitive function is mediated by various physiological mechanisms operating at the molecular, cellular, and systems levels. Nutrients serve as precursors for neurotransmitter synthesis (e.g., serotonin, dopamine), modulate neuroinflammatory processes, and influence neuronal membrane fluidity and ion channel function. Moreover, dietary factors can impact neurotrophic factors such as brain-derived neurotrophic factor (BDNF), which play a critical role in neuronal survival, synaptic plasticity, and cognitive function [9]. Additionally, gut-brain axis communication, mediated by the microbiota-gut-brain axis, influences cognitive processes through the production of neurotransmitters, neuroactive compounds, and inflammatory mediators.

Understanding the interplay between nutrition and cognitive function elucidates the importance of dietary interventions in optimizing brain health and supporting academic achievement. By promoting nutrient-rich diets and healthy eating habits, educators [10], policymakers, and healthcare professionals can empower students to enhance their cognitive abilities, maximize learning potential, and succeed academically. Moreover, integrating nutrition education into school curricula and implementing school-based nutrition programs can foster a supportive environment conducive to students' overall well-being and academic success.

III. Nutrition and Academic Performance

A. Evidence Linking Nutrition to Academic Achievement

Numerous studies have demonstrated a robust association between nutrition and academic performance across various age groups and educational settings. Research consistently shows that students who consume balanced diets rich in essential nutrients tend to exhibit better cognitive function, attention, and academic achievement compared to those with poor dietary habits [11]. Longitudinal studies have highlighted the predictive relationship between early childhood nutrition and later academic outcomes, underscoring the importance of nutritional interventions during critical periods of cognitive development. Additionally, cross-sectional

studies have identified positive correlations between dietary quality scores and standardized test scores, academic grades, and overall school performance, further emphasizing the impact of nutrition on educational attainment.

B. Effects of Specific Nutrients on Learning and Memory

Specific nutrients have been shown to exert distinct effects on learning and memory processes, influencing various cognitive domains critical for academic success. For instance, omega-3 fatty acids, particularly DHA, have been linked to improved attention, memory consolidation, and information processing speed. B vitamins, such as folate and vitamin B12, are essential for neural tube development, myelination, and neurotransmitter synthesis, affecting cognitive functions such as information processing, reasoning, and problem-solving. Furthermore, antioxidants like vitamin C and vitamin E protect against oxidative stress and neurodegeneration, preserving cognitive function and mitigating age-related cognitive decline. The synergistic interactions among these nutrients contribute to optimal brain health and support students' cognitive abilities necessary for effective learning and academic performance.

Nutrient	Effects on Learning and Memory
Omega-3 fatty acids (DHA)	Improves attention, memory consolidation, and information processing
B Vitamins (folate, vitamin B12)	Enhances information processing, reasoning, and problem-solving
Antioxidants (vitamin C, vitamin E)	Preserves memory capacity and cognitive function
Iron, Zinc, Magnesium	Supports memory, attention, and synaptic plasticity

Table 3: Effects of Specific Nutrients on Learning and Memory

C. Role of Dietary Patterns in Academic Success

Beyond individual nutrients, dietary patterns encompassing overall food choices and eating behaviors play a crucial role in shaping academic success. Diets characterized by diversity, balance, and moderation promote optimal cognitive function and academic achievement, while diets high in energy-dense, nutrient-poor foods are associated with poorer academic outcomes. Moreover, meal timing and frequency, such as regular breakfast consumption, have been shown to impact cognitive performance, attention, and classroom behavior. Cultivating healthy dietary habits early in life and maintaining them throughout adolescence is essential for sustaining cognitive function and academic success, highlighting the importance of promoting nutritious eating environments in schools and communities [12].

Understanding the complex interplay between nutrition and academic performance underscores the need for comprehensive strategies that address both individual dietary behaviors and broader environmental factors. By promoting a supportive food environment, integrating nutrition education into school curricula, and implementing evidence-based nutrition interventions, stakeholders can empower students to optimize their cognitive abilities, maximize learning potential, and achieve academic success [13]. Moreover, fostering collaboration among educators, policymakers, healthcare professionals, and families is essential for creating holistic approaches that prioritize students' nutritional well-being and educational outcomes.

IV. Nutritional Deficiencies and Academic Outcomes

A. Consequences of Inadequate Nutrition on Cognitive Development

Nutritional deficiencies, characterized by insufficient intake or absorption of essential nutrients, pose significant risks to cognitive development and academic outcomes. During critical periods of brain growth and maturation, such as infancy, childhood, and adolescence, inadequate nutrition can impair neurodevelopmental processes, leading to long-term cognitive deficits [14]. For example, iron deficiency, the most common nutrient deficiency worldwide, is associated with decreased cognitive function, attention deficits, and poor academic performance, particularly in children and adolescents. Similarly, deficiencies in vitamins such as folate and vitamin B12 have been linked to cognitive impairments, including reduced memory capacity, impaired information processing, and diminished academic achievement.

B. Impact of Micronutrient Deficiencies on Educational Attainment

Micronutrient deficiencies, including deficiencies in vitamins and minerals such as iodine, zinc, and vitamin A, can adversely affect educational attainment and lifelong learning outcomes. Iodine deficiency, for instance, impairs thyroid hormone synthesis, critical for brain development and cognitive function, leading to intellectual disabilities and learning difficulties. Zinc deficiency, essential for synaptic transmission and neurotransmitter regulation, has been associated with impaired memory, attention, and academic performance [15]. Furthermore, vitamin A deficiency compromises visual function and immune response, affecting cognitive abilities and school attendance. The burden of micronutrient deficiencies disproportionately affects vulnerable populations in low-resource settings, exacerbating educational disparities and perpetuating cycles of poverty and underdevelopment.

C. Socioeconomic Disparities in Nutritional Status and Academic Performance

Socioeconomic factors play a significant role in shaping nutritional status and academic outcomes, with disparities in access to nutritious foods, healthcare services, and educational opportunities contributing to inequalities in academic achievement. Children from socioeconomically disadvantaged backgrounds are more likely to experience food insecurity, inadequate dietary intake, and micronutrient deficiencies, placing them at higher risk for cognitive impairments and academic underachievement. Moreover, socioeconomic status influences environmental factors such as home environment, parental education, and neighborhood resources, which further impact nutritional well-being and educational success [16]. Addressing socioeconomic disparities through targeted interventions and policy initiatives is crucial for promoting equitable access to nutritious foods, improving health outcomes, and narrowing the achievement gap among students.

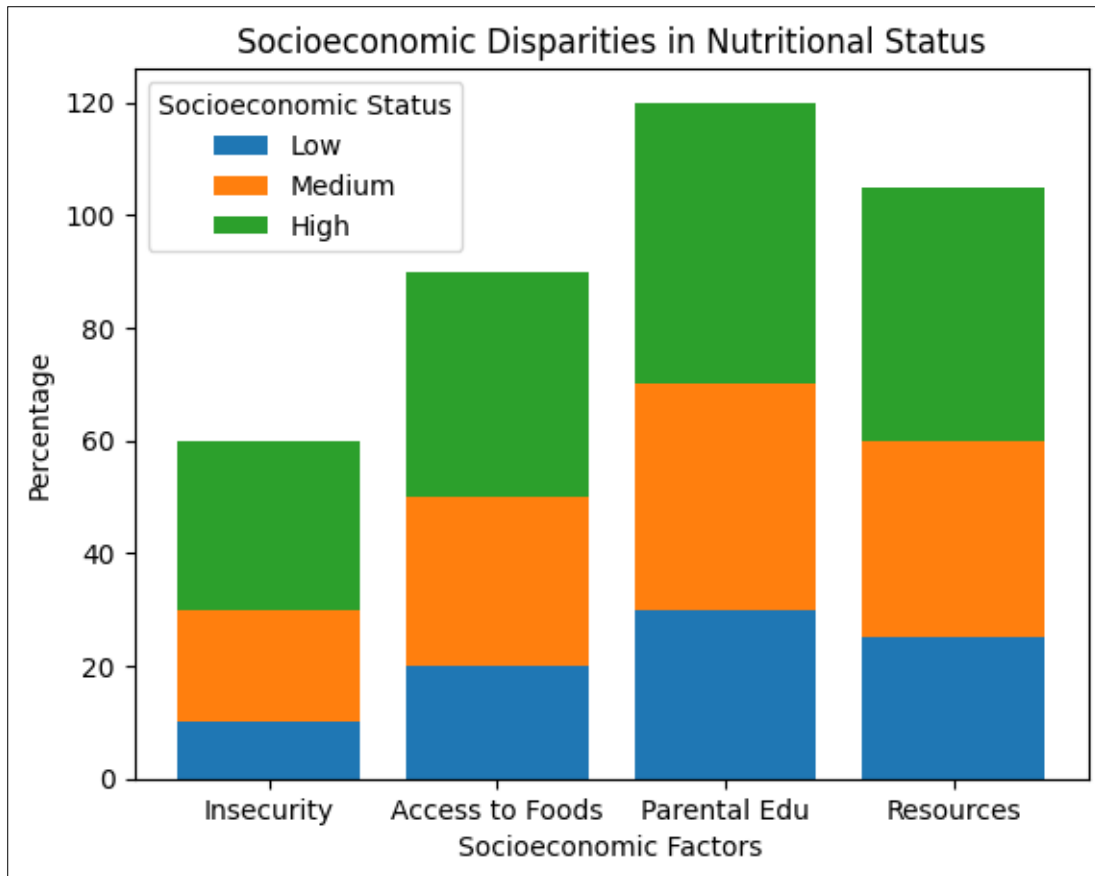


Figure 4. Socioeconomic Disparities in Nutritional Status

Recognizing the detrimental effects of nutritional deficiencies on cognitive development and academic outcomes underscores the importance of comprehensive approaches that address underlying socioeconomic determinants and systemic barriers to nutrition and education. By implementing evidence-based interventions, such as micronutrient supplementation programs, school meal initiatives, and community-based nutrition interventions [17], stakeholders can mitigate the adverse effects of malnutrition and support students' cognitive development, academic achievement, and long-term success. Moreover, fostering collaboration among diverse sectors, including education, health, and social services, is essential for implementing holistic strategies that promote equitable access to nutritious foods and educational opportunities, ensuring all students have the foundation they need to thrive.

V. School-Based Nutrition Programs and Interventions

A. Overview of Existing School Nutrition Initiatives

School-based nutrition programs and interventions play a pivotal role in promoting students' nutritional well-being and supporting academic success. These initiatives encompass a range of strategies aimed at improving access to nutritious foods, fostering healthy eating habits, and creating supportive food environments within educational settings [18]. Common examples include school meal programs, nutrition education curriculum, school gardens, and policies promoting the availability of healthy food options in cafeterias and vending machines. Additionally, initiatives such as breakfast programs, afterschool snacks, and summer meal

programs help address food insecurity and ensure students have consistent access to nutritious meals year-round.

B. Effectiveness of School Meals Programs in Improving Academic Outcomes

Research has consistently demonstrated the positive impact of school meals programs on students' academic performance, attendance, and behavior. Access to nutritious meals at school is associated with improved cognitive function, concentration, and classroom behavior, facilitating better learning outcomes. Moreover, participation in school breakfast programs has been linked to higher standardized test scores, reduced absenteeism, and improved academic achievement, particularly among disadvantaged students. By providing a reliable source of nutrition, school meals programs help alleviate hunger, support students' physical and mental well-being, and create an equitable learning environment conducive to academic success.

C. Strategies for Promoting Healthy Eating Habits Among Students

In addition to providing nutritious meals, schools play a crucial role in promoting healthy eating habits and empowering students to make informed dietary choices. Nutrition education curriculum, integrated into classroom instruction, equips students with essential knowledge and skills related to balanced nutrition, food preparation, and meal planning. School-based interventions, such as taste tests, cooking classes, and nutrition-focused events, engage students in hands-on learning experiences and encourage positive attitudes toward healthy eating. Furthermore, collaboration with parents, community partners, and local stakeholders enhances the effectiveness and sustainability of school-based nutrition initiatives, fostering a culture of health and wellness within the school community.

Stakeholder	Recommendations
Educators	Integrate nutrition education into the curriculum, incorporate healthy eating habits into classroom activities
Policymakers	Allocate resources to support school-based nutrition programs, enact policies promoting access to nutritious foods
Healthcare Professionals	Provide nutrition counseling, screenings for nutritional deficiencies, and referrals to community resources
Parents/Caregivers	Encourage healthy eating habits at home, reinforce nutrition education taught in schools

Table 4: Recommendations for Stakeholders

By leveraging the potential of school-based nutrition programs and interventions, stakeholders can address nutritional deficiencies, support students' academic success, and promote lifelong health and well-being. Investing in comprehensive strategies that prioritize nutrition education, access to healthy foods, and supportive food environments within schools is essential for fostering positive health behaviors, reducing health disparities, and empowering students to thrive academically and beyond. Moreover, fostering partnerships between schools, families, communities, and policymakers is critical for building sustainable, equitable approaches to promoting nutrition and academic achievement, ensuring all students have the opportunity to reach their full potential.

VI. Implications for Student Education

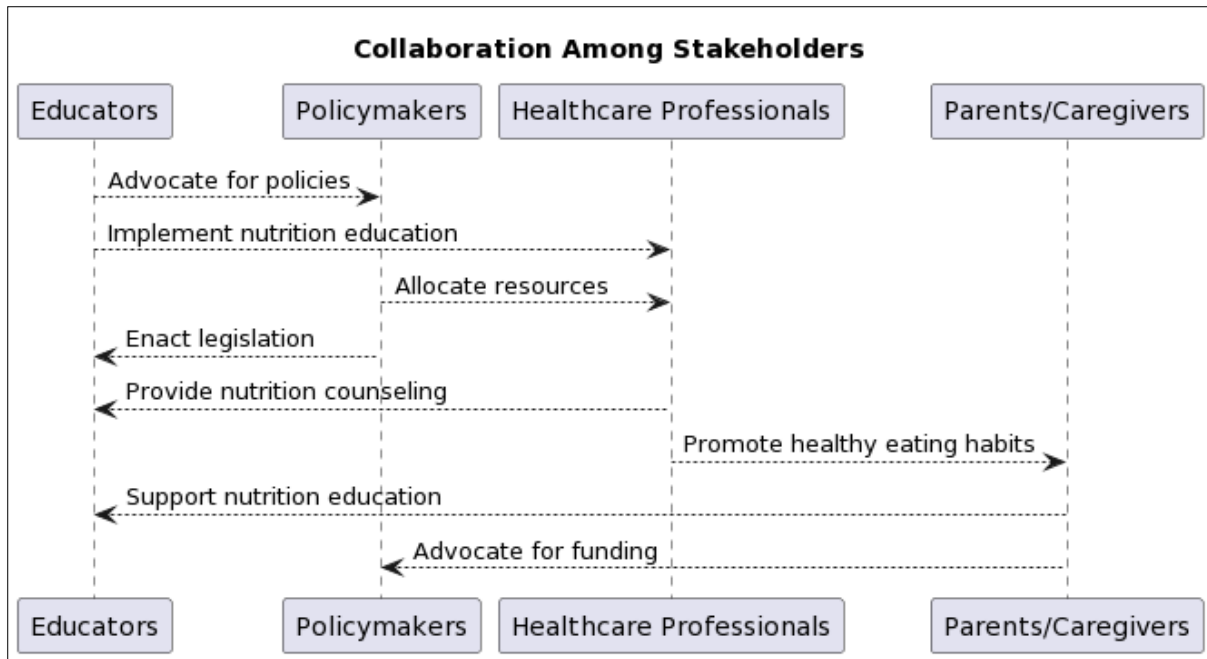


Figure 5. Collaboration among stakeholders

A. Recommendations for Educators, Policymakers, and Healthcare Professionals

Educators, policymakers, and healthcare professionals play vital roles in shaping students' educational experiences and overall well-being. In light of the significant impact of nutrition on academic performance, it is imperative for these stakeholders to prioritize nutrition education, advocacy, and policy development. Educators can integrate nutrition education into the school curriculum, incorporating lessons on healthy eating habits, food literacy, and the importance of balanced nutrition for academic success. Policymakers can enact legislation and allocate resources to support school-based nutrition programs, ensuring all students have access to nutritious meals and comprehensive wellness initiatives. Healthcare professionals can collaborate with schools to provide nutrition counseling, screenings for nutritional deficiencies, and referrals to community resources, addressing students' holistic health needs and promoting positive health behaviors.

B. Integration of Nutrition Education into the Curriculum

Embedding nutrition education into the school curriculum offers a holistic approach to promoting students' nutritional well-being and academic success. By incorporating nutrition concepts across various subject areas, educators can reinforce key messages about healthy eating habits, dietary choices, and the impact of nutrition on cognitive function. Integrating hands-on activities, interactive lessons, and real-world applications engages students in experiential learning experiences and empowers them to make informed decisions about their health. Moreover, fostering cross-disciplinary connections between nutrition, science, mathematics, and social studies enhances students' understanding of the multifaceted nature of nutrition and its implications for individual and societal health outcomes.

C. Importance of Collaboration Between Schools, Families, and Communities

Collaboration among schools, families, and communities is essential for creating supportive environments that promote students' nutritional well-being and academic success. Schools can engage parents and caregivers through family nutrition workshops, cooking demonstrations, and informational sessions, encouraging partnerships that reinforce healthy eating habits at home and in the community. Community organizations, such as local health departments, nonprofit agencies, and food banks, can provide resources, funding, and programming support for school-based nutrition initiatives, extending the reach and impact of these efforts beyond the classroom. By fostering a collaborative ecosystem of support, stakeholders can leverage collective expertise, resources, and networks to address systemic barriers to nutrition and education, creating lasting change and opportunities for all students to thrive.

Intervention	Description
School Meal Programs	Provide nutritious breakfast, lunch, and snacks to students, ensuring access to balanced meals during the school day
Nutrition Education Curriculum	Integrate lessons on healthy eating habits, food literacy, and nutrition concepts into the school curriculum
School Gardens	Create hands-on learning opportunities for students to grow fruits, vegetables, and herbs, fostering food literacy
Healthy Food Policies	Implement policies promoting the availability of healthy food options in cafeterias, vending machines, and school events
Community Partnerships	Collaborate with local organizations, food banks, and healthcare providers to support school-based nutrition initiatives

Table 5: School-Based Nutrition Programs and Interventions

The recognizing the profound influence of nutrition on academic performance underscores the importance of holistic approaches that prioritize students' nutritional well-being within educational settings. By implementing evidence-based strategies, integrating nutrition education into the curriculum, and fostering collaboration among diverse stakeholders, educators, policymakers, and healthcare professionals can empower students to make healthy choices, achieve academic success, and lead fulfilling lives. Embracing a comprehensive vision of student education that encompasses both physical and mental well-being ensures all students have the foundation they need to thrive academically, personally, and socially.

VII. Future Directions and Research Needs

A. Areas for Future Research to Further Explore the Link Between Nutrition and Academic Performance

While existing research provides valuable insights into the relationship between nutrition and academic outcomes, several areas warrant further investigation to deepen our understanding and inform evidence-based interventions. Future research should explore the longitudinal effects of dietary patterns on academic achievement, examining how sustained adherence to healthy eating habits influences cognitive development, educational attainment, and long-term academic trajectories. Additionally, studies examining the impact of specific nutrients and dietary interventions on diverse student populations, including those with varying socioeconomic backgrounds, cultural contexts, and nutritional needs, can help identify targeted strategies to address disparities in academic outcomes. Furthermore, interdisciplinary research approaches integrating nutrition science, education, psychology, and public health can provide comprehensive insights into the complex interactions between dietary factors, cognitive

function, and academic performance, informing holistic approaches to promoting student well-being and success.

B. Evaluation of Innovative Interventions and Policies Aimed at Improving Students' Nutritional Status and Educational Outcomes

Evaluating the effectiveness of innovative interventions and policy initiatives aimed at improving students' nutritional status and academic outcomes is essential for informing evidence-based practices and guiding future implementation efforts. Rigorous evaluation studies assessing the impact of school-based nutrition programs, community partnerships, and policy interventions on students' dietary behaviors, cognitive function, academic achievement, and overall well-being can provide valuable data on program effectiveness, scalability, and sustainability. Moreover, qualitative research exploring stakeholders' perspectives, experiences, and preferences regarding nutrition education, school meals programs, and environmental supports can inform the development of culturally responsive, contextually relevant interventions tailored to the needs of diverse communities. By fostering a culture of continuous learning and improvement, stakeholders can identify promising practices, address implementation challenges, and refine strategies to maximize the positive impact of nutrition on student education and health outcomes.

The stakeholders can advance our understanding of the complex interplay between nutrition and academic performance, inform evidence-based interventions, and contribute to the development of policies and practices that support students' holistic development and academic success. Investing in interdisciplinary collaborations, longitudinal studies, and rigorous evaluation methodologies is crucial for generating actionable knowledge that can inform effective strategies to address nutritional disparities, promote healthy eating habits, and empower all students to reach their full potential in school and beyond.

VIII. Conclusion

The intricate relationship between nutrition and academic performance underscores the critical importance of prioritizing students' nutritional well-being within educational settings. As evidenced by the extensive research reviewed in this paper, nutrition plays a fundamental role in supporting optimal cognitive function, concentration, and overall academic achievement. From the key nutrients essential for brain health to the implications of nutritional deficiencies on educational outcomes, the evidence is clear: what students eat profoundly influences how they learn. Moreover, school-based nutrition programs and interventions offer promising avenues for promoting students' nutritional health and academic success. By providing access to nutritious meals, integrating nutrition education into the curriculum, and fostering partnerships with families and communities, schools can create environments that support healthy eating habits and empower students to thrive academically. Looking ahead, it is imperative for educators, policymakers, and healthcare professionals to continue advancing research, implementing evidence-based interventions, and advocating for policies that prioritize students' nutritional well-being. By embracing a holistic vision of student education that recognizes the interconnectedness of physical and mental health, we can create learning environments that nurture students' holistic development and equip them with the tools they need to succeed academically, personally, and socially. The investing in nutrition education, school-based nutrition programs, and collaborative partnerships is not only an investment in students' academic success but also in their long-term health and well-being. By working

together to foster a culture of health and wellness within schools and communities, we can empower all students to reach their full potential and thrive in school and beyond.

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