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# Role of School-Based Nutrition Education in Empowering Healthier Communities

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## Abstract
Education is a multi-faceted concept that emphasizes on the ability to reflect on own knowledge, skills and abilities. National Education Policy (NEP) 2020 focuses on skill-based learner-centered approaches moving away from rote memorization. Nutrition education is a key tool in promoting healthier lifestyles and reducing the burden of nutritional deficiency among population. This paper examines the impact of integrating nutrition education in schools, aligning with NEP 2020 objectives and supporting the broader vision of "Viksit Bharat" promoting well-being across the nation. Targeting school children (6-18 year of age), intervention studies and survey studies were analyzed based on effective approaches and educational tools used to enhance learning outcomes. The data was explored using databases such as Web of Science, Google Scholar, PubMed, and Scopus etc. Results indicated significant improvement in the nutritional knowledge ($p < 0.01$), attitudes and behaviors ($p < 0.05$) towards healthy eating choices with increased consumption of nutrient rich foods, better meal frequency, enhanced physical activity, reduced junk food consumption among school students. Various studies reported that school-based nutrition education interventions lead to significant reduction in biochemical parameters ($p < 0.001$) among target group. The study concluded that integrating nutrition education in schools plays a crucial role in shaping the perspective of students towards health and well-being leading to healthy dietary choices among students. Integrating experiential learning and parental engagement in these initiatives could further enhance their effectiveness in tackling malnutrition to prevent non-communicable diseases and contributing to build healthier communities.

**Keywords:** Nutrition Education, Health, Nutrient Deficiency, School Education, Experiential Learning.

## Introduction

### 1.1 Educational Transformation in India

Education is a multi-faceted concept emphasizes on the ability to reflect on own knowledge, skills and abilities not limited to retrievable knowledge **(Bartsch S et al., 2024)**. It significantly impacts nation's economic growth, individual income levels, and the overall social well-being of its citizens. Education enables individuals to enhance opportunities for personal growth and improve quality of life **(Singh D. S. S. 2024)**. The National Education Policy (NEP) 2020, a landmark initiative by the Government of India, is a comprehensive framework that seeks to revolutionize the country's educational landscape focusing on learner-centered approach that fosters critical thinking, creativity, and problem-solving skills, while moving away from rote memorization **(Shukla T.D. et al., 2023)**. This enriched curriculum integrates India's diverse cultural heritage, traditional knowledge systems, and local practices. Simultaneously, it must integrate modern educational perspectives developed by curriculum theorists over the past century **(Bhardwaj, M et al., 2024).**

### 1.2 Importance of School-Based Nutrition Education

In the pursuit of fostering healthier lifestyles among the children, school-based nutrition education initiatives have gained widespread recognition and implementation across diverse cultural and socioeconomic landscapes worldwide **(UNESCO,2023)**. At early stage, children are confronted with various risk factors, including inadequate nutrition, and unstimulating home environments, which can hinder their development and detrimental effects can persist throughout a child's lifetime, affecting not only their behavior, education, income, and social well-being but also impacting the national economy. Early interventions for children focused on overall development have been proven to positively impact their lives, improving their experience during school and extending to better job opportunities and higher income in the future **(Hossain, S. J. et al., 2024)**.

**1.3 Burden of malnutrition in India**

India contributes to one third of the total global burden of malnutrition, due to its vast population size. Reducing malnutrition is the prominent area to be focused upon to achieve Sustainable Development Goal- 2 which aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture by 2030 **(Monaco, S. 2024)**. Gradually, over the years, due to rapid industrialization, large number of populations have altered their dietary patterns and lifestyles and has led to an inappropriate weight gain and various diseases such as hypertension, cardio-vascular diseases, obesity, diabetes, PCOD, etc. known as Non-Communicable Diseases (NCD) **(Geetha R., et.al., 2022)**. According to the study report, "India: Health of the Nation's States"- The India State-Level Disease Burden Initiative by Indian Council of Medical Research (ICMR) in 2017, it is estimated that the proportion of deaths due to NCDs in India have increased from 37.9% in 1990 to 61.8% in 2016 **(ICMR,2017)**. This not only affects the physical health but also the quality of life contributes to decrease in life expectancy, adding to the financial burden to the family and the society **(Geetha R., et.al., 2022)**.

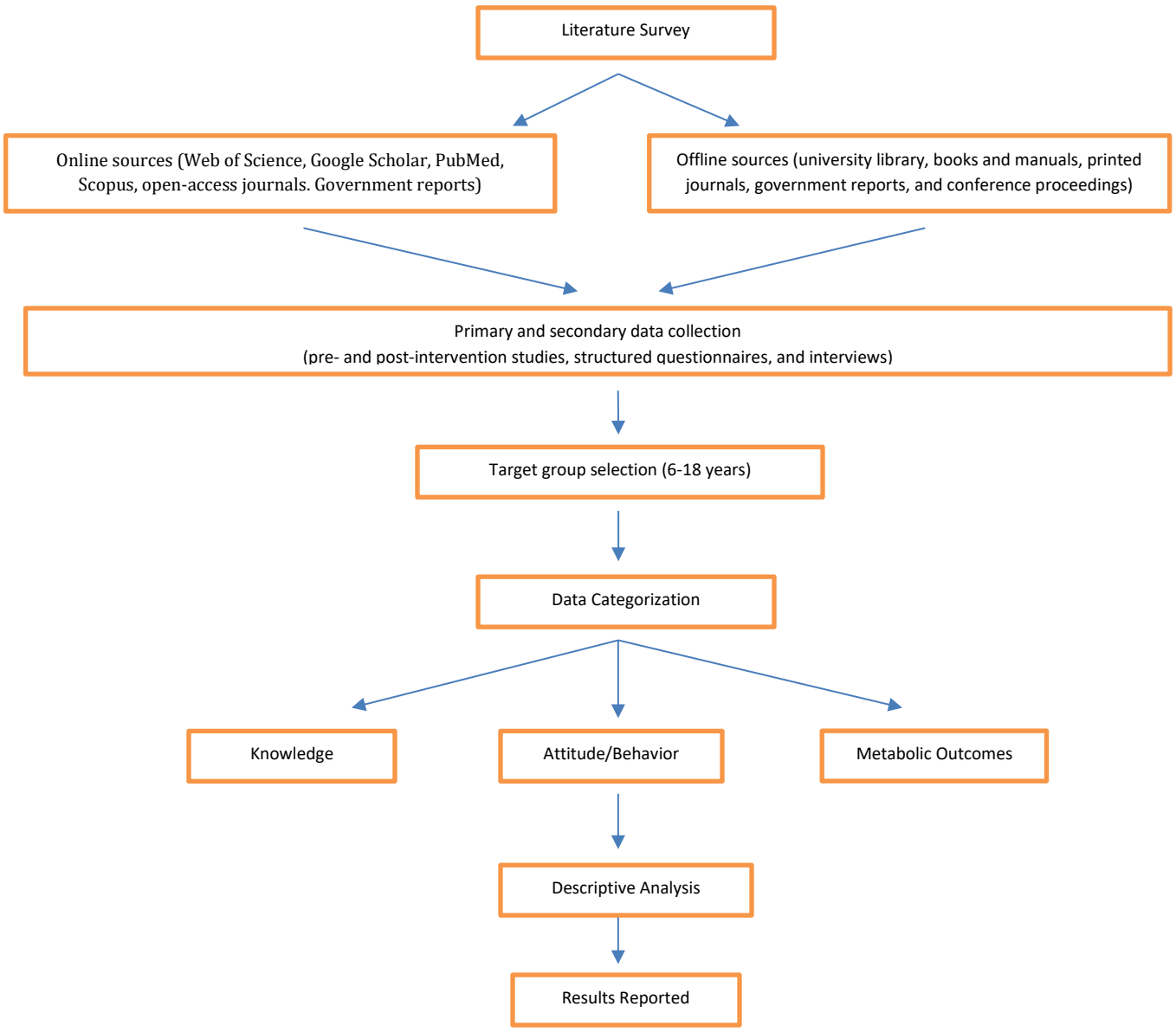
As per Comprehensive National Nutrition Survey (CNNS) 2016-2018, about 41% of preschoolers (1-4 years), 24% of school-age children (5-9 years) and 28% of adolescents (10-19 years) were found to be anemic in India **(CNNS, 2019)**. Additionally, the prevalence of anemia among six groups as per the NFHS- 5 (2019-21), was 25.0 % in men (15-49 years) and 57.0 % in women (15-49 years), 31.1 % in adolescent boys (15-19 years), 59.1 % in adolescent girls (15-19 years), 52.2 % in pregnant women (15-49 years) 57.2 % in non-pregnant women (15-19 years) **(NFHS, 2021)**. The Increasing prevalence of anemia is the major public health concern in India, especially among adolescent females (13-19 years of age). Majorly nutritional anemia is caused due to lack of essential nutrients in the diet such as iron, folate, vitamin B12 etc. which impose long term complications affecting growth and development, work productivity, school performance, increased school dropouts, further poor pregnancy outcomes in later stages of life **(Dhuppar P. et al., 2017)**. Various government initiatives have been proven to be effective in reducing the rate of prevalence among females, but regardless of these initiatives many studies have revealed gap in the nutritional knowledge and awareness about anemia in young adolescent females. Educational intervention to educate girls about iron deficiency anemia and its preventive measures may built positive attitude towards healthy eating and behavioral change was observed among school going girls **(Salam, S. S. et al., 2023).**

**1.3.1 The Role of Nutrition Education in Addressing Malnutrition**

Imparting nutrition education is a process proven to be effective in inculcating healthy eating practices among individuals, improving decision making to choose nutritious foods, practicing regular fitness regimen, educating about the importance of nutrition, portion control and its role in managing chronic diseases **(Maheshwar, M et al., 2024).** Regarding the dietary habits, researches has demonstrated that imparting education based on nutrition in schools can effectively influence student food choices and consumption patterns, leading to improvements in nutrient intake and reducing the prevalence of unhealthy dietary practices **(Teo et al., 2021).** The aim of this paper is to examine the impact of integrating the nutrition education into schools, aligning with the objectives of NEP 2020 and supporting broader vision of "Viksit Bharat" promoting well-being across the nation.

**Methodology**

A comprehensive literature survey was conducted using both online and offline resources. The online sources included Web of Science, Google Scholar, PubMed, Scopus, ERIC, and various open-access journals. Whereas, offline sources included the university library, books, manuals, printed journals, government reports, and conference proceedings etc. The data was collected from both primary and secondary sources and included pre- and post-intervention studies. These studies employed methods such as structured questionnaires, focus group discussions, observational studies and interviews and interventions that incorporated classroom-based learning, experiential learning, and parental involvement. Various Government reports from the Ministry of Health and Family Welfare, National Institute of Nutrition (NIN), and ICMR were also included. The inclusion criteria for study selection encompassed research that evaluated school-based nutrition education interventions, targeted children and adolescents in a school setting, and reported quantitative outcomes related to knowledge, nutritional behavior, or metabolic parameters. Studies were excluded if they did not provide a clear description of the intervention or its outcomes, were conducted outside a school setting, focused solely on non-nutrition-related interventions, or were published in languages other than English. Data quality was ensured through manual cross-checking of studies across multiple databases (PubMed, Scopus, Web of Science, and Google Scholar). Studies were reviewed independently by both authors to confirm relevance, eliminate duplicates, and verify the consistency and clarity of reported outcomes. Discrepancies were resolved through discussion and consensus. The target population for the study was 6-18 years old school children from diverse cultural and socioeconomic settings. Relevant data was extracted and categorized into three distinct categories: Knowledge, Attitude/Behavior, and Metabolic Outcomes. Impact of the nutrition education was analyzed based on these three key parameters. A descriptive analysis of the data was done, and based on that results were summarized.




## 3. Results and Discussion

### 3.1. Comparative analysis among home-based and school-based nutrition education

Understanding a comparative impact of both home-based and school-based nutrition education plays a pivotal role in shaping the strategies focusing on improving the dietary habits among children and its overall health outcomes. **Fig. 1.** depicts a comparative analysis of home-based and school-based nutrition education. These two approaches, emphasize their unique strengths, limitations, and synergistic potential in fostering healthier eating behaviors among children. The findings are supported by various intervention studies.

Home-based nutrition education is generally conducted within a home environment, known to be informal and unstructured form of teaching **(Van, Lippevelde. et al., 2012)**. The Knowledge, Attitudes and Practices (KAP) model emphasizes on the acquisition of knowledge is the foundation of beliefs and attitudes that reinforce the intention to adopt healthy behaviors **(Liu, K. S. N. et al., 2021)**. Various studies have reported that the parental dietary practices, knowledge about nutrition, beliefs of parents and home food environment such as availability and accessibility of healthy food, significantly influence children's eating habits and influences health status of the child. Moreover, a family environment surrounding a child's domestic life plays an active role in establishing and promoting behaviors that can last throughout their lifetime **(Mahmood, L. et al., 2021)**. Moreover, **Robert L. Nix et al. (2021)** reported that positive parenting combined with sensitive scaffolding involving children in adopting healthy eating pattern can develop self-regulation among children at early age. However, nutrition education imparted by parents at home is effective in providing personalized guidance that is deeply rooted in cultural traditions and is aligned with home environment. However, its effectiveness and reliability are influenced by the level of nutritional knowledge and perspectives of parents. In contrast, the school-based nutrition education is generally conducted within an educational institution with formal and structured curriculum based on scientific evidences, eliminating personal beliefs and choices **(Antwi, J. et al., 2020)**. The

content is delivered by trained teachers, ensuring consistency and reliability in in the dissemination of scientifically accurate nutrition knowledge and the promotion of healthy eating behaviors among children **(Asakura, K. et al., 2021)**. However, various studies reported that eating behaviors among school going children are also influenced by peer groups and group activities, which can shape their food preferences, dietary choices, and overall eating patterns in both positive and negative ways **(Upreti, Y. R. et al., 2023)**. However, the differences between these approaches emphasize their unique strengths and challenges, highlighting their roles in shaping children's nutritional knowledge and behaviors. Implementing nutrition education interventions in schools for children in early age has been associated with increased autonomous motivation for physical activity and improved self-efficacy for healthy eating in later period of life Moreover, this review highlights that focusing on both home based and school-based nutrition education can create a synergistic effect on enhancing knowledge, attitudes, and practices towards healthy eating among children.

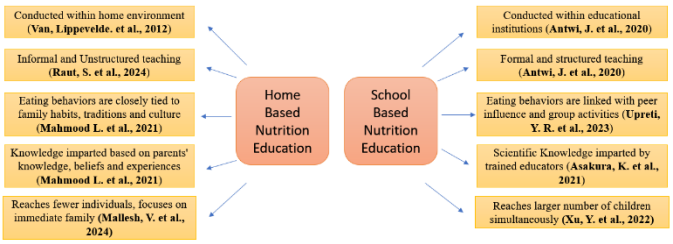



***Fig. 1. Comparative Analysis of Home-Based and School-Based Nutrition Education***

### 3.2 Impact of School-Based Nutrition Education

Nutrition is an integral component of various initiatives/programmes such as Mid-Day Meal Programme, ICDS, Anemia Mukt Bharat, Poshan Abhiyaan, Eat Right School Initiative, School Health & Wellness Programme, PM POSHAN Scheme etc. Various studies reported that nutrition interventions administered through government are beneficial to build healthier communities **(Raut, S et al., 2024)**. However, these initiatives primarily focus on providing immediate solutions to malnutrition rather than fostering long-term knowledge and encouraging sustainable behavioral changes. **Upreti, Y. R et al. (2023)** suggested that implementing school-based nutrition education programme (SBNEP) among school children (Grades 1–8) by using participatory action research (PAR) may build transformational change in the nutritional behaviors**.**

This section highlights the impact of school-based nutrition education on various parameters such as nutrition knowledge, attitudes, behaviors and metabolic effect. Relevant findings on the nutrition education intervention outcomes across diverse settings among different age groups are reported in **Table 1**.

**Table 1 Nutrition Education Intervention Outcomes**

| Sr. No. | Description of interventions | Educational materials used | Duration of session | Age/grade of sample | Effect on nutrition knowledge | Effect on Attitudes, Behaviors | Metabolic Effect | References |
|---|---|---|---|---|---|---|---|---|
| 1. | Mini lectures, 45 min of nutrition education sessions a day per week | Posters, Leaflets, pamphlets, educational videos, and power point presentation | 12 weeks | 12-19 years | Significant improvement in knowledge (score 1.80 (95% Ci: 1.11 – 2.49), | Significant improvement in healthy eating choices, Emotional eating was 0.98 (95% ci: 0.42 – 1.54), uncontrolled eating was 3.60 (95% ci: 2.10 – 5.09), and Cognitive restraint of eating was 2.26 (95% ci: 1.51 – 3.01). | | **(Raut, S. Et al., 2024)** |
| 2. | Balanced diet, the significance of macro and micronutrients, and Physical activity. | Audiovisual aids including powerpoint presentation, models, charts, Posters, leaflets, pamphlets, and handouts. | 8 weeks | 12-17 years | A significant improvement in students' knowledge levels ($p \leq 0.01$). | - | | **(Maheshwar, M. et al., 2024)** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3. | School nutrition program (snp) based on health awareness, nutrition, physical activity, and food hygiene | | 3-month | 7–11 years | Enhanced nutrition knowledge | Increased frequency of breakfast, lunch, and dinner consumption and morning tea snacking and showed more frequent physical activity and better cognitive performance ($p < 0.05$) | Lower body mass index-for-age (baz) ($p < 0.05$) | **(Teo et al., 2021)** |
| 4. | Seven half-hour educational sessions | Lectures, role play and practical demonstrations | 7 weeks | 10-18 years | Increase in awareness | A positive attitude towards changing behavior | | **(Salam, S. S. Et al., 2023)** |
| 5. | Importance of nutrition, the prevalence of anemia and Its risk factors etc. | Small group discussions, q&a, practical Demonstration , videos, powerpoint, and booklet in 45–50 min of six sessions | 4 months | 7th and 8th-grade high school Students | Increased awareness about anemia, risk factors etc. | Enhanced anemia preventive behaviors in female students | No significant difference in The mean score of haemoglobin , haematocrit, and ferritin Blood. | **(Khani Jeihooni, A. Et al., 2021)** |
| 6. | Pre-tested, structured, and self-administered questionnaires was used to access knowledge, attitude, and practice regarding anemia | Poster, power-point presentation, songs, videos, role play, demonstration and drawing | 3 months | 5-6 grade students/ 10–13 years | Significant improvement in the knowledge was observed ($p<0.05$). Significant improvement on both knowledge and positive attitude about anemia ($p < 0.05$). | Increase in frequency of consumption pattern of iron rich foods especially ragi, jaggery, green leafy vegetables and sprouted grains was reported | | **(Sasmita A. P. Et al., 2022)** |
| 7. | Structured questionnaire and interactive lectures | Powerpoint presentations and videos, lectures, brochures | 1 month | 13–15 years | 52.4% exhibited adequate knowledge, 45% Engaged in healthy practices, and 42.7% had a positive attitude toward iron deficiency anemia ($p<0.05$) | Nutrition education programme effectively improves knowledge, attitude, and practice regarding ida among Adolescent females. | | **(Abu-baker, N. N. Et al., 2021)** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8. | Nutrition education and physical activity intervention given by teachers and caregivers | | 8 months | 9.8 ± 0.7 years | | Improvements in risk of poor well-being ($p$ = 0.051), social anxiety ($p$ = 0.029). | Decreased diastolic blood pressure ($p$ = 0.020) and fasting plasma glucose ($p$ < 0.001), significantly increased high-density lipoprotein ($p$ < 0.001) from baseline to post-intervention | **(Yu, H. Et al., 2019)** |
| 9. | Self-developed Questionnaire was used to access knowledge and awareness followed by awareness session by interactive activities and quizzes | | 10 months | 8-14 years | Significant improvement in the knowledge about importance of iron increased from 27.30% to 59.50%, iron deficiency anaemia from 34.03% to 59.85%, sources of iron from 25.20% to 51.70%, iron absorption from 36.00% to 61.2% and knowledge of fortification from 55.4% to 76.9% ($p \leq 0.001$). | | | **(Bharti, R. Et al., 2021)** |
| 10. | Texas sprouts intervention (cooking intervention on dietary intake) was done, garden leadership committees were formed, focused on school-based gardening, nutrition education. | Raised vegetable beds; in-ground native and Herb beds; a large shed for tools and materials; a white-Board; materials and supplies needed for gardening | 1year | 3-5 Grade | Increased gardening, nutrition, cooking knowledge. | Increased self-efficacy, attitudes, willingness to prefer fruits and vegetables. | Reduction in obesity and adiposity measures, reduction in blood pressure and type 2 diabetes risk | **(Davis, J.N. et al., 2021)** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11. | Nutrition education intervention curriculum was developed focused on combining classroom based learning and experiential learning with interactive environment. Students were taught how fruits and vegetables are processed and used to prepare healthy meals. | | 3 weeks | 5-8 year | A significant increase in knowledge (p=0.001) was observed. | A significant improvement in the taste preference (p=0.002)m attitude towards assessed fruits/vegetable product (p=0.004), attitude towards adopting healthy products (p=0.01) | | **(Hahnraths M. T. H. et al., 2022)** |
| 12. | A school meal program that combined with dietary and educational interventions were used. Educational intervention was conducted 2-3 times per month for a total of 25 sessions. Knowledge, Attitude, and Practice (KAP) was assessed. | Posters and banners | 9 months | 13 and 18 years | | Increased intake of protein, iron, vitamin C rich foods were observed among the participants. | significant increase in the hemoglobin level and a reduction in the prevalence of anemia from 42.6% to 21.7%. | **(Rimbawan R. et al., 2023)** |
| 13. | Nutrition education focused on dietary diversity (eating a variety of foods), energy adequacy (eating breakfast and healthy snacks), and healthy food choices (avoiding junk foods). | | 4 months | 10-14 years | Improved practices and knowledge related to dietary diversity and meal frequency among young adolescent girls. | Decrease in the consumption of junk food among young adolescent girls was observed. | | **(Kim, S. S. et al., 2023)** |

**3.2.1 Impact on Nutrition Knowledge**

The analysis of intervention outcomes summarised in **Table 1** depicts a significant improvement in nutrition knowledge among participants. **Raut, S. Et al. (2024)** observed a notable increase in nutrition knowledge scores (score 1.80, 95% Ci: 1.11 − 2.49) among adolescents aged 12–19 years after 12 weeks of imparting structured nutrition education using materials like posters, pamphlets, videos, and presentations. These resources provided engaging, visually clear information, enhancing knowledge retention. As, various studies suggest that parental nutrition knowledge and beliefs significantly influence children's eating habits **(Mahmood, L. et al., 2021)**. Imparting nutritional knowledge to parents may fostering healthier eating practices within the family environment. **Maheshwar, M. et al., (2024)** reported a significant improvement ($p < 0.01$) in knowledge among 12–17-year-old students following an education program on balanced diets, macro and micronutrients, physical activity, and related health benefits. Similarly, **Teo et al. (2021)** reported improved nutrition knowledge among 7–11-year-old children after a 3-month school program covering health awareness, nutrition, physical activity, and food hygiene. Moreover, **Davis, J.N. et al. (2021)** reported improved gardening skills, nutrition, and cooking knowledge among 3rd–5th graders after a year-long Texas Sprouts Intervention, which included school gardening, nutrition education, and cooking activities. **Sasmita A.P. et al. (2022)** reported a significant improvement ($p < 0.05$) in knowledge among 10–13-year-old students (5th–6th grade) assessed using structured, self-administered questionnaires on anemia-related knowledge, attitude, and practice. Similarly, **Bharti, R. et al. (2021)** found significant increases ($p \leq 0.001$) in knowledge about iron's importance (27.3% to 59.5%), iron deficiency anemia (34.03% to 59.85%), iron sources (25.2% to 51.7%), iron absorption (36.0% to 61.2%), and fortification (55.4% to 76.9%) among 8–14-year-old school children. However, **Hahnraths, M.T. H. et al. (2022)** developed a Nutrition Education Intervention Curriculum combining classroom and experiential learning on healthy meal preparation, reported significant improvement in knowledge ($p = 0.001$) among 5–8-year-olds. Additionally, **Kim, S.S. et al. (2023)** reported improved knowledge and practices on dietary diversity, meal frequency, energy adequacy, and healthy food choices among 10–14-year-old girls after a targeted nutrition education intervention focused on dietary diversity (eating a variety of foods), energy adequacy (eating breakfast and healthy snacks), and healthy food choices (avoiding junk foods). **Fig. 2** represents the key factors influencing nutritional knowledge in children, encompassing individual, familial, societal, and institutional influences. These studies underscore the pivotal role of nutrition education in equipping children with the beneficial knowledge, laying the foundation for improved health outcomes.

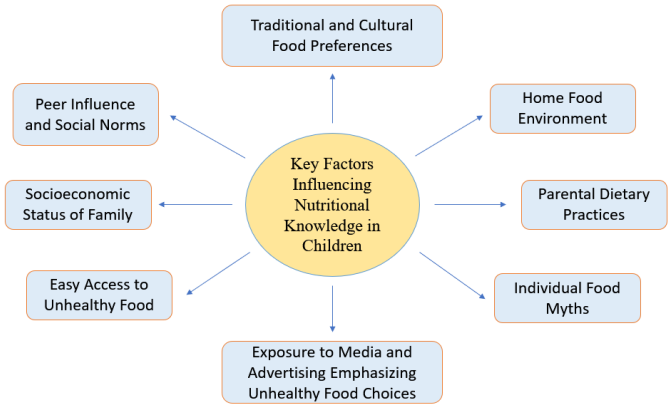



***Fig. 2. Key Factors Influencing Nutritional Knowledge in Children***

**3.2.2 Impact on Attitude and Behavioral Outcomes**

The analysis of the various intervention outcomes summarised in **Table 1** emphasizes that imparting nutrition education to children significantly improved attitudes and behaviors toward healthier eating practices. **Raut, S. Et al. (2024)** reported significant improvements in healthy eating choices (mean score 0.98, 95% CI: 0.42–1.54), emotional eating (3.60, 95% CI: 2.10–5.09), uncontrolled eating (2.26, 95% CI: 1.51–3.01), and cognitive restraint among 12–19-year-olds after weekly 45-minute nutrition education sessions. The study suggests that nutrition education positively impacts eating patterns. Additionally, **Teo et al., (2021)** found an improved meal frequency, physical activity, and cognitive performance ($p \leq 0.001$) among 7–11-year-old children, suggesting that school nutrition programs can positively influence healthy eating behaviors and attitudes. **Salam, S.S. et al. (2023)** and **Khani Jeihooni, A. et al. (2021)** both found positive changes in attitudes and behaviors toward iron-rich foods and anemia prevention among female students (10–18 years and 7–8th grade, respectively) after nutrition education through lectures, role play, and practical demonstrations. These studies highlight the impact of nutrition education on young females' dietary behaviors and attitudes. Moreover, **Davis, J.N. et al. (2021)** reported increased self-efficacy, improved attitudes, and a greater preference for fruits and vegetables over junk food among 3rd–5th grade students after participating in the year-long Texas Sprouts Intervention, which included cooking activities, school gardening, and nutrition education. However, **Hahnraths, M.T. H. et al. (2022)** developed a Nutrition Education Intervention Curriculum focused on combining classroom based learning and experiential learning with interactive environment. Students learned about fruit and vegetable processing and healthy meal preparation, resulting in significant improvements in taste preference ($p = 0.002$), attitudes toward fruits/vegetable products ($p = 0.004$), and adopting healthy eating habits ($p = 0.01$). The study emphasizes that experiential learning and classroom-based learning can shape children behavior and attitude towards healthy eating instead of unhealthy eating pattern. These studies highlight that effective nutrition intervention strategies can reduced emotional and uncontrolled eating behaviors while fostering self-efficacy and a willingness to prefer fruits and vegetables. However, a positive behavioral change demonstrates the practical application of nutritional knowledge, as participants actively avoided unhealthy food options and incorporated diverse, nutritious foods into their diets. **Fig. 3** represents impact of

nutrition education interventions on attitudes and behaviors in children. Overall outcomes highlighted the potential of imparting nutrition education to in school foster healthy eating habits in children.

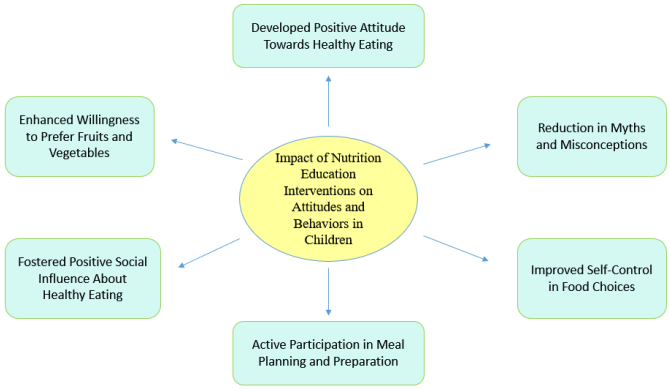



***Fig. 3. Impact of Nutrition Education Interventions on Attitudes and Behaviors in Children***

### 3.2.2 Impact on Metabolic Outcomes

The analysis of the various intervention outcomes summarised in **Table 1** emphasizes that imparting nutrition education to children on directly influence metabolic outcomes. **Teo et al., (2021)** reported a significant reduction ($p < 0.05$) in body mass index-for-age among 7–11-year-old children, suggesting that school nutrition programs can effectively help maintain a healthy BMI by promoting behavioral changes and encouraging healthier eating habits. Similarly, **Yu, H. et al. (2019)** reported a decrease in diastolic blood pressure ($p = 0.020$) and fasting plasma glucose ($p < 0.001$), along with a significant increase in high-density lipoprotein ($p < 0.001$) after 8 months of nutrition education and increased physical activity provided by teachers and caregivers. The study suggests that fostering healthy eating habits in children early on can lead to improved metabolic outcomes. **Rimbawan, R. et al. (2023)** reported a significant increase in hemoglobin levels and a reduction in anemia prevalence from 42.6% to 21.7% among 13–18-year-olds after a school meal program combined with dietary and educational interventions. The educational sessions, conducted 2-3 times per month over 25 sessions, assessed Knowledge, Attitude, and Practice (KAP). This study suggests that effective educational interventions can improve metabolic outcomes in children. Similarly**, Jacob, C.M. et al. (2021)** highlighted that school-based nutrition interventions, focusing on diet, physical activity, and body composition, are essential for maintaining a healthy BMI and fostering healthier communities. **Fig. 4** represents Impact of Nutrition Education on Metabolic Outcomes in Children. These findings underscore the potential of nutrition education intervention as a preventative approach to non-communicable diseases and nutrient deficiencies among school children.

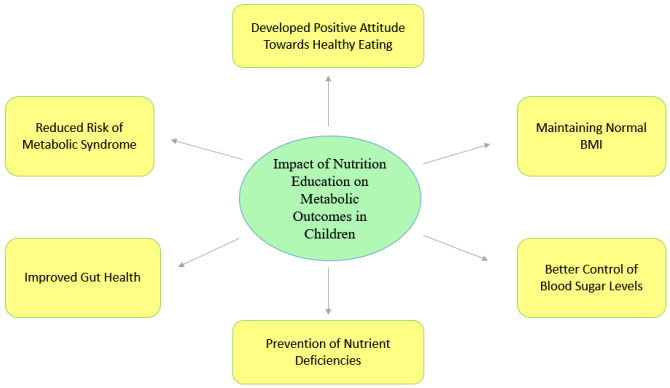



***Fig. 4. Impact of Nutrition Education on Metabolic Outcomes in Children***

### 3.3 Effective Approaches

Various studies suggest several effective approaches for implementing school-based nutrition interventions are depicted in **Fig. 5**. **Chan, C.L. et al., (2022)** suggested that school garden-based programme (SGBP) focusing on gardening activities demonstrated beneficial effects on the nutritional knowledge and practical experience-based learning among children. **Davis, J.N. et al. (2021)** reported an enhancement in knowledge, attitude and practices among school children, through the Texas Sprouts Intervention, combining cooking education with garden leadership committees. The gardening education included experiential participative approach such as raising vegetable beds in kitchen garden; preparing in-ground native and Herb beds, plucking of grown fruits, vegetables and herbs etc. Promoting learning of sustainable food production through kitchen gardening can significantly improve the frequency and willingness to consume fruits and vegetables among children **(Kim, J et al., 2021)**. However, incorporating school gardening can significantly transform children's perceptions and improve access to nutritious foods, especially in low-income communities **(Landry, M. J. et al., 2021)**.

Additionally, participatory cooking demonstrations foster skill building and self-efficacy among children and proven to be highly effective in improving understanding of healthy eating and food preparation **(Korfiatis, K. et al., 2021)**. These hands-on activities allow students to learn practical skills for preparing nutritious meals, which not only enhances their cooking abilities but also encourages healthier food choices **(Ali et al., 2022)**. The use of age-appropriate educational materials, such as posters, pamphlets, audio-visual aids, educational games and quizzes, ensures better engagement and knowledge retention among students **(Raut, S. Et al., 2024)**. Interactive discussions, mini-lectures, and presentations have proven to be effective methods for delivering nutrition education to school children. These approaches facilitate active engagement, enhance understanding of nutritional concepts, and promote healthy eating behaviors among students **(Khani Jeihooni, A. Et al., 2021)**. These approaches collectively demonstrate that school-based nutrition interventions can effectively shape healthier behaviors combined with scientific knowledge engaging children in experiential participative learning.

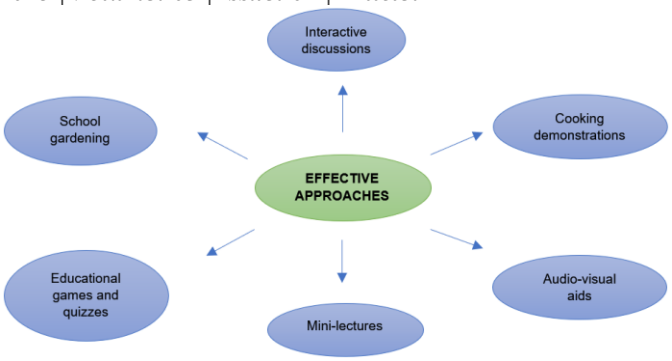



***Fig. 5. Effective approaches for enhanced learning***

### 3.5 Impact of school-based nutrition education on Communities

School-based nutrition education has the potential to significantly impact not only the students but also their families and the wider community. By equipping children with the knowledge and skills to make healthier food choices, such interventions fostering positive changes within the family and local community. Sustainable dietary patterns are affordable, accessible, safe, equitable and are generally culturally acceptable which promotes health and well-being, contributes to less environmental impact, emphasized on balanced diet intake and prevent chronic disease in later life **(Bartsch S et al., 2024).** Nutrition education is essential for deepening understanding of its health benefits and encouraging healthier eating habits to promote overall well-being **(Maheshwar, M et al., 2024)**. Involving parents in imparting nutrition education leads to a transformative impact on family dietary behaviors. By fostering a deeper understanding of nutrition, these programs help counteract the adverse effects of nutrition transition, where families shift away from traditional, nutrient-dense foods towards processed alternatives. This comprehensive approach not only enhances children's nutrition but also improves family health, contributing to broader community well-being **(Huang, L., et al., 2021)**. These interventions not only promote healthy eating habits but also help prevent nutrition-related diseases, such as obesity, diabetes, and cardiovascular conditions, by fostering long-term behavioral changes. By influencing both students and their families, school-based interventions contribute to improved public health outcomes and the development of sustainable, health-conscious communities **(Ash, S. et al., 2023)**.

The observed improvements in nutritional knowledge and healthier eating behaviors are consistent with the Health Belief Model, which suggests that increased awareness of health risks and benefits motivates behavioral change **(Alyafei, A., & Easton-Carr, R., 2024)**. As students became more aware of the benefits of nutrient-rich foods, they were more likely to choose these options over less healthy alternatives. Similarly, Social learning theory (SLT) and social cognitive theory (SCT) emphasizes the importance of observational learning **(Firmansyah, D., & Saepuloh, D., 2022)**. Our findings showed that group-based nutrition education sessions not only improved knowledge but also significantly improved behaviour of students towards healthy eating emphasizing the importance of interactive learning environment in achieving sustained behavioral change and positive metabolic outcomes.

### 3.6 Innovative Approaches and Future Directions

The future of nutrition education in schools lies in embracing innovative approaches that enhance the engagement, reach, and impact of interventions. The integration of modern technologies and evidence-based practices offers promising avenues for improving student learning outcomes. Artificial intelligence (AI) and digital tools offer personalized learning experiences by analyzing students' eating habits and providing tailored nutritional advice, interactive lessons, and real-time feedback **(Yim, I.H.Y. et al., 2024)**. Expanding school-based garden programs using smart technologies allows students to connect with food production, promoting healthier eating habits. For these innovations to be widely implemented, policy integration and national frameworks must support technology integration in curricula, ensure access to digital tools, and involve parents in reinforcing healthy behaviors at home **(F. Zhang.et al., 2024)**. These approaches promise to revolutionize nutrition education, fostering healthier behaviors and building a sustainable foundation for future generations.

## Conclusion

School-based nutrition education serves as a cornerstone for empowering healthier communities. By integrating nutrition education interventions at school level, the findings underscore the potential of structured and experiential learning to significantly enhance nutritional knowledge, attitudes, and behaviors. To maximize impact, the incorporation of innovative approaches, such as school gardening, participatory cooking demonstrations, and technology-driven learning tools, are essential. Furthermore, practical applications such as organizing parental workshops, community events, and specialized teacher training programs have been proven essential bridging gaps in accessibility and scalability, addressing diverse socioeconomic contexts while ensuring sustainable behavior change and long-term public health improvements. Parental involvement and community engagement further amplify the effectiveness of these interventions, ensuring sustainable behavior change and long-term public health benefits. By aligning these approaches with the goals of NEP 2020 and the broader vision of "Viksit Bharat," we can build a healthier, more sustainable future for India's children, empowering them to make lifelong health-promoting decisions.

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