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A Systematic Literature Review on Nutritional Meals for School Children and the Implications for Public Policy in Indonesia

Nonnytha Mahananny*, Wahyu Aditama Putra Mukti Wibawa, Maria Carisita Suci Puspa Pranasari, Kurnia Aviati, Irine Puspita Sasmitaningsih
Universitas Airlangga, Indonesia
Email: dr.nonnytha2@gmail.com*

ABSTRACT

This study aims to evaluate the nutritional needs of school children in relation to Indonesia's Free Nutritious Meal (Makan Bergizi Gratis/MBG) policy through a systematic literature review approach. Twenty-six scientific articles from various countries, published between 2015 and 2025, were selected using the PRISMA 2020 method. Inclusion criteria comprised: (1) articles from the last ten years (2015–2025), (2) explicit discussion of nutritional needs for elementary to secondary school children, (3) examination of school food program contributions to children's nutritional fulfillment, and (4) full-text availability in English. Data synthesis employed thematic analysis across five categories: macronutrient contribution, micronutrient adequacy, cognitive impacts, dietary behavior, and policy effectiveness. Results demonstrate that school meals consistently contribute significantly to meeting children's needs for energy (16.4–33%), protein (>33% of daily requirements), iron, calcium, fat, fiber, and vitamin D. School feeding programs positively impact cognitive function (improvement in reading comprehension, p = 0.043) and reduce ultra-processed food consumption by 6.8 percentage points, particularly among low-socioeconomic groups. Program success is strongly influenced by menu diversity, children's preferences, physical activity levels, and public policy support. This research contributes to formulating evidence-based MBG policies that consider actual nutritional needs, socio-cultural contexts, and behavioral dynamics of children. In conclusion, MBG has great potential as a national strategy to improve nutritional status and equitable food access for school children, but successful implementation requires a multidimensional approach and localized studies.

KEYWORDS *school children; school meal; dietary; makanan bergizi gratis (MBG) - free nutritional meal; government program.*

INTRODUCTION

School feeding programmes aim to provide nutritious food to children and adolescents at school (Cupertino et al., 2022; Wang & Fawzi, 2020). Since children spend a considerable part of their day at school and have at least one meal there, good-quality meals have the potential to improve children's diet and health (Horta et al., 2019).

Poor nutrition during this period adversely affects the physical and mental health of the children, thereby limiting their academic performance. Studies have reported high rates of undernutrition among school-aged children (SAC) (Zailani et al., 2023). Undernutrition during school age is a significant contributor to poor health and academic performance. Indeed, suboptimal intake of essential nutrients contributes significantly to undernutrition among SAC (Zailani et al., 2023).

The importance of nutritional fulfillment through school meal programs is not only seen in its contribution to energy and macronutrient adequacy but also from its impact on micronutrient status, which is crucial in supporting immunity, bone health, and brain development in children. Children in developed countries such as Sweden and Denmark still show deficiencies in vitamin D, iron, and fiber despite having access to subsidized school meals

(Osowski et al., 2015; Petersen et al., 2015). This demonstrates that the mere availability of food does not guarantee the adequacy of its nutritional quality. Structured supplementation of animal protein and essential fatty acids through school meals can improve children's nutritional status and cognitive abilities (Al-Ghannami et al., 2016; Lee et al., 2018).

The implementation of free food policies in the UK and Scotland has increased the consumption of healthy foods while reducing the consumption of ultra-processed foods, especially among lower economic groups (Parnham et al., 2024). Similar contexts in Nigeria, Ghana, and Asian countries such as South Korea and Japan also indicate that school lunch programs have significant potential to meet the energy, protein, and micronutrient needs of school-age children (Zailani et al., 2023; Agbozo et al., 2018; Sung et al., 2024; Shinsugi & Takimoto, 2023).

Studies in Canada and Malaysia show that a child's diet is strongly influenced by family eating habits, food availability at school, and social interactions during mealtimes (Selamat et al., 2020; Ziraldo et al., 2025). Thus, it is important for Indonesia to design an MBG program that is not only nutritionally adequate but also aligned with the local socio-cultural context.

According to the Financial Media Portal (February 2025), the nutritional adequacy rate meeting the target of 30–35% of daily energy is only 17%. Research by the Center for Indonesia's Strategic Development Initiatives (CISDI), examining 29 food menu samples from several locations, found many processed foods high in salt and sugar content (Purwowidhu et al., 2025). This reveals a critical gap: the lack of comprehensive, evidence-based evaluations of school children's actual nutritional needs in Indonesia, specifically related to MBG policy design.

There is a pressing need for more accurate evaluation methods of children's protein and micronutrient requirements. The commonly used nitrogen balance method tends to underestimate real needs (Wang et al., 2025; Hudson et al., 2021). Furthermore, energy and protein requirements of school-age children depend heavily on age, gender, and physical activity levels, meaning the "one menu for all" approach in the MBG program carries a high risk of causing nutritional intake imbalances. Excessive protein intake without proper control raises concerns about overweight and metabolic stress (Madrigal et al., 2021). Therefore, an age-group-based approach considering eating habits must be integrated into MBG policy.

The nutritional adequacy of school children is a fundamental aspect in supporting optimal growth, development, academic achievement, and long-term health quality of the younger generation. In the Indonesian context, this issue is increasingly relevant alongside the government's policy to implement the Free Nutritious Meal (MBG) program nationally for all elementary to high school students since January 2025. This initiative aligns with various global interventions that have demonstrated success in increasing children's nutritional intake, reducing social disparities, and strengthening national education foundations.

While previous international studies have examined school feeding programs in various contexts, no systematic review has specifically synthesized global evidence to inform Indonesia's MBG policy design. This study uniquely bridges international best practices with Indonesia’s specific challenges, providing a contextualized framework for evidence-based policy formulation. The novelty lies in: (1) comprehensive synthesis of recent (2015–2025) global evidence on school nutrition programs; (2) specific focus on policy implications for

Indonesia's newly launched MBG program; and (3) integration of nutritional, behavioral, and policy dimensions rarely combined in previous reviews.

This study aims to systematically evaluate nutritional needs of school children based on recent international evidence; assess the contribution of school meal programs to children's macro- and micronutrient fulfillment; examine the impact of school feeding interventions on children's health, cognition, and dietary behavior; identify critical success factors for school meal program implementation; and develop evidence-based recommendations for Indonesia's MBG policy design and implementation.

The effectiveness of school meal programs highly depends on the accuracy of nutrition planning, availability of local foodstuffs, and children's acceptance of the provided menus (Sipple et al., 2021; Lee et al., 2018). Therefore, a systematic, in-depth study of school children's nutritional needs and their implications for Indonesia's MBG program is both important and urgent. This study is expected to: (1) provide a scientific foundation for MBG menu standardization; (2) inform budget allocation and program monitoring mechanisms; (3) guide integration of nutritional education with meal provision; and (4) contribute to reducing childhood malnutrition and educational disparities in Indonesia.

METHOD

This study uses the Systematic Literature Review (SLR) approach by referring to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines as a standard for reporting and implementing systematic reviews. This design was chosen because it allows researchers to thoroughly and systematically examine the results of previous research relevant to the topic of nutritional needs of school children and their implications for the free nutritious eating (MBG) policy in Indonesia.

The literature identification process was carried out by browsing five main electronic databases, namely Scopus, PubMed, Web of Science, ScienceDirect, and ProQuest, which resulted in 5,676 articles. After removing 1,564 duplicate articles, as well as automatic screening of 788 irrelevant articles, 3,324 articles remain for manual filtering. Articles that did not match the topic and context (n=3,201) were eliminated, so that only 123 articles were continued to the retrieval stage. Of these, three articles were inaccessible, and 120 articles were analyzed for eligibility. After assessing the content and suitability of the inclusion-exclusion criteria, a total of 26 articles were declared eligible to be included in this review.

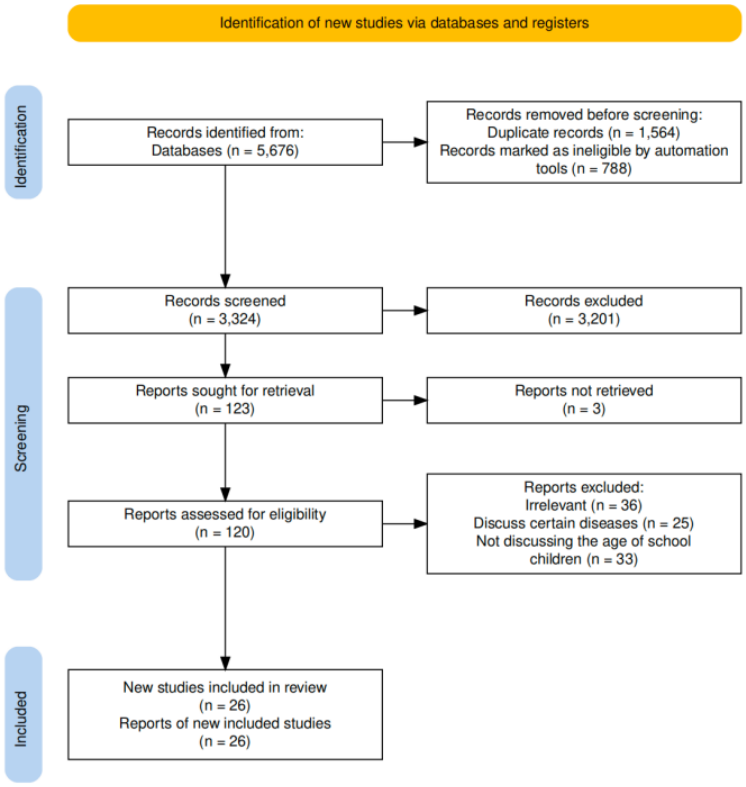

Figure 1. Prisma flow diagram of selection criteria

The inclusion criteria set include: (1) articles in the last ten years (2015–2025), (2) articles that explicitly address the nutritional needs of elementary to secondary school children, (3) articles that examine the contribution of school food programs to child nutrition fulfillment, and (4) studies that are available in full text and written in English. Instead, exclusion criteria include: articles that focus only on specific diseases, do not mention the age group of school children, or do not relate to school meal policies or programs. The research instrument in this SLR is in the form of a systematic search protocol using a combination of keywords such as "school feeding program", "nutritional needs of school children", "free school meal policy", and "dietary intake school-aged children" which is adjusted to the syntax of each database.

Quality appraisal was performed using the JBI (Joanna Briggs Institute) Critical Appraisal Checklist appropriate for each study design. Two reviewers independently assessed each included article for methodological rigor, risk of bias, and reporting quality. Any discrepancies were resolved through discussion and consensus. Studies were not excluded based on quality scores but were weighted accordingly in the synthesis process.

Data extraction was conducted systematically using a standardized form capturing: study characteristics (author, year, country, design, sample size), participant demographics (age, gender, socioeconomic status), intervention details (program type, duration, meal composition), and outcomes (nutritional intake, health indicators, cognitive measures). Thematic synthesis followed a three-stage coding process: (1) initial line-by-line coding of findings, (2) development of descriptive themes through code grouping, and (3) generation of analytical themes addressing the review objectives. Five major themes emerged: macronutrient contribution, micronutrient adequacy, cognitive and health impacts, dietary behavior changes, and policy effectiveness factors.

The data collection procedure was carried out through the stages of identification, screening, eligibility, and inclusion as in the PRISMA diagram. All articles that passed the final stage were analyzed qualitatively using a narrative synthesis approach based on key themes including: the contribution of macro and micronutrients, their impact on children's health and cognition, and their relevance to public policy and cost-effectiveness. This analysis aims to build a conceptual and empirical framework that can support evidence-based policymaking for school nutrition programs, particularly Indonesia's MBG initiative.

RESULT AND DISCUSSION

This study successfully identified and reviewed 26 scientific articles from various countries that are relevant to the theme of nutritional needs of school children and their relation to school feeding programs. These results are presented in the form of a thematic narrative that divides key findings into several important aspects: energy adequacy, macro and micronutrients such as protein, fat, iron, calcium, vitamins and fiber, as well as social and public policy factors in designing effective and sustainable school meal programs.

Table 1: Summary of Literatur Review of the Articles

Title	Year	Result
What do Danish children eat, and does the diet meet the recommendations? Baseline data from the OPUS School Meal Study	2011	• A total of 834 children participated in the study, with 798 completing the dietary assessment sufficiently. • The assessment was conducted over seven consecutive days using the Web DASC tool. • Results indicated that 85% of children consumed excess red meat and 89% too much saturated fat. • Additionally, 96% of children had insufficient vitamin D intake. • The study found higher fruit and bread intake during school hours compared to outside school hours.
Vitamin D status and its determinants during autumn in children at northern latitudes: a cross-sectional analysis from the optimal well-being, development and health for Danish children through a healthy New Nordic Diet (OPUS) School Meal Study	2015	• The study evaluated autumn vitamin D status in 782 Danish children aged 8-11 years, finding mean serum 25(OH)D levels of 60.8 nmol/l. • Serum 25(OH)D levels ≤50 nmol/l were found in 28.4% of children, with 2.4% having concentrations <25 nmol/l. • Positive associations with 25(OH)D were observed for moderate-to-vigorous physical activity and frequent intake of vitamin D supplements. • The findings highlight the importance of vitamin D status in children, especially during winter months.
Sex differences in the associations of dietary protein intake with lean mass and grip strength in children and adolescents	2025	• Higher protein intake positively correlated with appendicular lean mass index (ALMI) and combined grip strength in children and adolescents • Significant associations were particularly pronounced in boys aged 8-11 years • Multivariate regression analyses confirmed robust positive correlations between protein intake and musculoskeletal health indicators
Secular trends in dietary energy, carbohydrate, protein and fat intake among Korean children and adolescents	2011	• The study analyzed trends in macronutrient intake among Korean children and adolescents over a decade, revealing significant dietary changes. • Total energy intake significantly decreased, while fat intake proportion increased during the survey period. • Subgroup analysis showed consistent increases in total fat intake across age, sex, and obesity status [1].

Title	Year	Result
		• Insufficient dietary fiber intake and increased intake of all fat subtypes were also observed. • The findings indicate potential risks of diet-related diseases due to changing dietary patterns.
Nutritional value of school meals and their contributions to energy and nutrient intakes of rural school children in Enugu and Anambra States, Nigeria	2015	• The study evaluated school meals in three rural schools for their adequacy in meeting one-third of the recommended daily nutrient intake. • Results indicated that nutritional deficiencies among school children were linked to inadequate nutrient intake from meals. • The meals provided were designed to alleviate hunger and support cognitive development in school-aged children. • Statistical analysis showed significant differences in nutritional status among children, with rural children being more stunted than urban counterparts.
Evaluating the impact of the universal infant free school meal policy on the ultra-processed food content of children's lunches in England and Scotland: a natural experiment	2024	• The study evaluated the impact of the UIFSM policy on children's UPF intake during school lunchtime. • It found a reduction in UPF intake and an increase in minimally processed food intake. • School meal uptake increased by 25 percentage points after the UIFSM policy implementation. • The greatest improvements in dietary intake were observed in low-income children. • The study highlights the need for policies to enhance school meal quality and uptake.
Effect of a free healthy school meal on fruit, vegetables and unhealthy snacks intake in Norwegian 10-to 12-year-old children	2020	• Serving a free healthy school meal for one-year increased vegetable intake on sandwiches in the intervention group compared to the control group. • No significant changes were observed in the intake of other fruits and vegetables. • The intervention did not lead to a lower intake of unhealthy snacks among the children. • The study suggests that even moderate improvements in vegetable intake have public health relevance. • Overall, the intervention was associated with a higher weekly intake of vegetables but did not significantly alter other dietary behaviors.
Trends in Mean Energy and Nutrient Intakes in Japanese Children and Adolescents: The National Health and Nutrition Survey, 1995-2019	2023	• The study describes national trends in mean energy and nutrient intakes in Japanese children and adolescents from 1995 to 2019. • A declining trend in mean energy intake was observed in toddlers, schoolgirls, and adolescent girls. • Mean protein, fat, and carbohydrate intakes changed little over time. • Declining trends in mean vitamin and mineral intakes were noted, including vitamin A, B12, folate, calcium, and copper. • The 2019 mean calcium intake was lower than the recommended dietary allowance for young girls and adolescents. • Continuous monitoring of dietary intake is necessary to improve children's health. 1.

Title	Year	Result
Dietary Protein Requirements in Children: Methods for Consideration	2021	• The paper suggests that the RDA for protein in children aged 6-10 years may be around 1.55 g•kg −1 •day −1. • Current DRIs indicate children aged 4-13 years require 0.95 g•kg −1 •day −1 for protein intake. • There is insufficient literature on protein requirements for minimally and highly active children. • Newer methods like stable isotope techniques may provide better estimates of protein needs. • Physical activity is identified as a factor that increases protein requirements for children.
Dietary Intake, Nutritional Adequacy, and Food Sources of Protein and Relationships with Personal and Family Factors in Spanish Children Aged One to <10 Years: Findings of the EsNuPI Study	2021	• The study found that dietary protein is crucial for growth and development in early childhood. • Spanish children aged one to <10 years had high protein intake, exceeding European recommendations. • The protein contribution to total energy intake was significant, with 16.79% for SRS and 15.63% for AMS cohorts. • Future research should explore long-term effects of protein intake on health and growth. • Findings should inform public health policies to improve children's dietary habits.
Effect of Increasing the Dietary Protein Content of Breakfast on Subjective Appetite, Short-Term Food Intake and Diet-Induced Thermogenesis in Children	2020	• Increasing dietary protein in breakfast improved satiety and reduced food intake in children aged 9-14 years. • Higher diet-induced thermogenesis was observed after high protein breakfast compared to control. • All protein treatments suppressed subjective appetite compared to the control group. • The study found that protein-rich meals produce larger thermogenic effects than carbohydrates or fats.
Processed Food Contributions to Energy and Nutrient Intake Differ among US Children by Race/Ethnicity	2015	• Processed foods contribute 66% to 84% of daily energy and nutrient intake in children. • All children, regardless of race or ethnicity, consume processed foods. • Dietary recommendations should focus on nutrient content rather than processing levels. • The study analyzed data from 10,298 children aged 2-18 years. • Minimally processed foods provide essential nutrients while reducing added sugars and sodium. • The findings suggest dietary disparities among different race/ethnic groups. • The study emphasizes the importance of energy and nutrient composition in children's diets.
Nutrient intakes of Canadian children and adolescents at school by meal occasion and location of food preparation	2024	• Canadian children consume 32.6% of their daily energy intake at school, with nutrient intakes ranging from 28.4% to 35.6%. • Most children (98.6%) consumed foods at school that did not require preparation. • Lunch and snacks were the most frequently consumed meal occasions at school, reported by 85.5% and 66.1% of children. • The study highlights the need for improved school nutrition programs focusing on lower sugar and sodium, and higher calcium, fiber, and iron. • Dietary intake patterns at school remained consistent from 2004 to 2015.

Title	Year	Result
Objectively Measured Physical Activity and Sedentary Time are Differentially Related to Dietary Fat and Carbohydrate Intake in Children	2018	• The study found that sedentary time (ST) was positively associated with percent dietary fat intake and negatively with carbohydrate intake and glycemic load. • Moderate-to-vigorous intensity physical activity (MVPA) was positively associated with percent dietary carbohydrate intake and daily glycemic load. • The research indicates that physical activity may lead to a higher proportion of total intake from carbohydrates, particularly those with a higher glycemic index. • Results suggest the need for further research on the implications of these behavioral interrelations for diabetes, cardiovascular, and obesity risk.
Effects of school meals with weekly fish servings on vitamin D status in Danish children: Secondary outcomes from the OPUS (Optimal well-being, development and health for Danish children through a healthy New Nordic Diet) School Meal Study	2015	• The school meals increased vitamin D intake by 0.9 μg/d without consistent effects on serum 25(OH)D or bone markers. • Seasonal variations affected 25(OH)D status, with higher levels in January/February compared to control periods. • School meals slightly increased parathyroid hormone levels compared to habitual lunches. • The study involved 784 children and assessed various health markers over two dietary periods. • The findings suggest small dietary vitamin D increases may help mitigate winter declines in children's vitamin D status.
Dietary Practices and Meal Patterns among Overweight and Obese School Children in Malaysia: Baseline Data from a School-Based Intervention Study	2019	• The study involved 1045 primary and 1041 secondary overweight and obese school children in Malaysia. • Results indicated higher adequate intake of cereals among primary (54.7%) than secondary (48.2%) children. • Only 28.2% of primary and 32.6% of secondary children consumed adequate fruit. • A very low percentage of children consumed adequate vegetables: 5.0% primary and 3.6% secondary. • School children did not take breakfast regularly, averaging 3.16 days/week for primary and 2.97 for secondary. • The study highlighted the need for urgent actions to address dietary practices among overweight and obese children.
Diet-induced changes in iron and n-3 fatty acid status and associations with cognitive performance in 8–11-year-old Danish children: secondary analyses of the Optimal Well-Being, Development and Health for Danish Children through a Healthy New Nordic Diet School Meal Study	2015	• The intervention improved 'school performance' and 'reading comprehension' significantly (P = 0.015 and P = 0.043). • EPA + DHA status increased by 0.21 w/w % (95% CI 0.15, 0.27) (P < 0.001). • No significant changes were observed in serum ferritin or Hb levels. • Baseline EPA + DHA status correlated positively with 'school performance'. • The study included 726 children with sufficient data for analysis.

Title	Year	Result
Consuming school meals improves Brazilian children's diets according to their social vulnerability risk	2019	• The study involved 1357 children aged 8-12 years, with 51% male and 49% female participants. • 78.1% of children were aged ≤10 years, and 52.3% lived in low/medium social vulnerability areas. • 27.9% of children reported not consuming school meals ≥3 times/week. • School meal consumers lived more frequently in high/very high social vulnerability areas (76.2%) compared to low/medium areas (68.7%). • Consuming school meals was linked to higher thiamin intake (1.13 mg) compared to non-consumers (1.04 mg). • School meal consumers had lower candy intake (1.35 g) than non-consumers (1.42 g). • Higher vitamin C consumption was observed among school meal consumers (31.9 mg) compared to non-consumers (24.1 mg). • School meal consumers ate more unprocessed foods (956.3 g) than non-consumers (851.9 g). • The study concluded that school meal consumption improved diet quality, especially for children in higher vulnerability risk areas
Associations of dietary carbohydrate and fatty acid intakes with cognition among children	2020	• Higher dietary intake of fructose is associated with better cognition in boys, with a standardized regression coefficient of $\beta = 0.24$, $P < 0.001$. • Total fiber intake also positively correlates with cognition in boys ($\beta = 0.16$, $P = 0.02$). • Soluble fiber intake shows a similar positive association with cognition in boys ($\beta = 0.15$, $P = 0.02$). • Other dietary carbohydrates and fatty acids did not show significant associations with cognition in either boys or girls. • Dietary factors appear to have a stronger effect on cognition in boys compared to girls
Nutrient composition and dietary diversity of on-site lunch meals, and anthropometry of beneficiary children in private and public primary schools in Ghana	2018	• The study assessed dietary diversity and nutrient composition of school lunches in Ghana, aiming to meet FAO nutrient intakes for children aged 3-12 years. • Meals in public schools were generally more nutritious than those in private schools, despite no significant nutrient content difference. • Nutritional inadequacies were noted, particularly in protein, B vitamins, calcium, and zinc. • The meals were heavily reliant on energy-dense staples and lacked diversity in protein sources like eggs, meat, and fruits. • The prevalence of malnutrition indicators was low among participants, indicating a need for enhanced dietary diversity.
The contribution of school meals to energy and nutrient intake of Swedish children in relation to dietary guidelines	2015	• The study found that energy and nutrient intakes from school meals did not meet reference values for several nutrients. • Children in Grade 5 failed to reach reference values for folate, potassium, calcium, magnesium, iron, selenium, and zinc. • Saturated fatty acids and sodium intake exceeded reference values in both age groups. • Nutritional issues identified included the quality of fat, dietary fiber, sodium, vitamin D, and iron. • Some results may stem from underreporting or omitting meal components

Title	Year	Result
Lipid-soluble nutrient status of healthy Omani school children before and after intervention with oily fish meal or re-esterified triacylglycerol fish oil	2015	• The study found that the Omani diet has shifted to a high-calorie, low-nutrient density Western diet over two decades. • Children aged 9 and 10 were recruited to assess fat-soluble nutrient status before and after dietary intervention. • The intervention involved providing children with either grilled fish, fish oil capsules, or no fish for 12 weeks. • The results indicated changes in nutrient status due to the dietary interventions, although specific outcomes were not detailed in the provided contexts
Milk Powder Added to a School Meal Increases Cognitive Test Scores in Ghanaian Children	2018	• The study enrolled 1041 children, with 939 having HAZ outcomes and 883 completing CANTAB testing. • Children receiving 8.8 g milk protein showed improved cognitive function on specific tests. • No significant differences in linear growth were observed between supplement groups. • The Milk8 group had lower decreases in fat-free mass compared to controls. • The trial suggests milk protein may benefit cognition in vulnerable populations. • Improvements in cognitive scores were correlated with changes in body composition. • The study indicates that milk protein supports lean body mass accretion. • Overall, 8.8 g milk protein improved executive function but not linear growth.
Postexercise Dietary Protein Ingestion Increases Whole-Body Leucine Balance in a Dose-Dependent Manner in Healthy Children	2017	• The study found a dose-dependent increase in whole-body leucine balance after protein ingestion post-exercise in children. • Leu BAL was significantly higher for 15 g (24.2 mg/kg) compared to 10 g (11.6 mg/kg) and 5 g (5.7 mg/kg). • All protein conditions (5, 10, and 15 g) significantly differed from the 0-g condition ($P < 0.001$). • Exploratory analyses showed a main effect for condition on absolute Leu BAL over 3 hours ($P < 0.001$). • Co-ingestion of carbohydrates and 5 g protein promoted a positive post-exercise protein balance.
Child preferences and perceptions of fluid milk in school meal programs	2020	• The study identified intrinsic and extrinsic attributes influencing children's perceptions and consumption of fluid milk at school. • Children preferred milk packaged in HDPE bottles with cow graphics and blue color, labeled as low-fat. • Extrinsic factors like package type were most important, while intrinsic factors included flavor differences based on packaging. • The research highlights the need for appealing milk products to improve consumption in school meal programs. • A significant portion of milk served in schools is wasted, indicating a need for better product appeal.

Title	Year	Result
Contribution of school meals to the recommended nutrient and energy intake of children enrolled in the National Homegrown School Feeding Program in Zaria, Nigeria	2023	• The NHSFP meals in Zaria included moimoi, jollof rice, and yogurt, served on specific weekdays. • Major components were cereals and legumes, with no fruits, meat, or fish. • Portion sizes showed no significant differences between boys and girls, except on Tuesdays. • Meals contained moisture, ash, fat, protein, fiber, and carbohydrates, with energy ranging from 183.6 to 330.57 kcal. • Micronutrient content included calcium, potassium, sodium, iron, zinc, vitamin A, and vitamin C. • Meals contributed significantly to the RNI for several nutrients but not for carbohydrates, fiber, potassium, and vitamin C. • The study highlighted the need for increased portion sizes and meal diversity.

In general, it was found that school meals make a significant contribution to children's energy and nutrient needs. Studies in Nigeria show that school meals contribute positively to protein, iron, vitamin A, sodium, and energy needs, even though they are not sufficient in fiber, potassium, vitamin C, and carbohydrates (Zailani et al., 2023). School meals contribute between 16.4%--25.5% of daily energy and one-third of protein needs (Ayogu et al., 2018). Meanwhile, a study in Ghana noted that fat and energy requirements have been met, but there are deficiencies in calcium, protein, riboflavin, and niacin, indicating the persistent challenge of micronutrient inadequacy in developing countries (Agbozo et al., 2018).

In the aspect of micronutrients, evidence shows that children in Sweden and Denmark have not reached adequate intakes of vitamin D, iron, and fiber. As many as 96% of Danish children are deficient in vitamin D intake and 86% are deficient in fiber, despite having access to school meals (Osowski et al., 2015; Andersen et al., 2015). A study in Oman demonstrated that oily fish supplementation increases vitamin D levels in children aged 9--10 years. These findings show that school meals have the potential to serve as effective interventions against common micronutrient deficiencies (Al-Ghannami et al., 2016).

Important findings also came from animal protein-based interventions, demonstrating improvements in cognitive performance and lean body mass from an additional 8.8 g of daily milk protein intake (Lee et al., 2018). A study in Canada found that a high-protein breakfast reduced energy intake at lunch and increased diet-induced thermogenesis (Bellissimo et al., 2020). High protein intake is positively correlated with appendicular lean mass index (ALMI) and grip strength in children aged 8--11 years (Wang et al., 2025).

Most studies emphasize the importance of controlling fat intake, particularly saturated fat, as it contributes to the risk of metabolic diseases and childhood obesity. A study of children in Denmark found that about 60--70% of children exceeded the recommended limit of saturated fat intake, even though they received meals from school canteens (Andersen et al., 2015). This suggests that although school meals can meet energy needs, the distribution of the types of fats contained in those foods is still not ideal (Andersen et al., 2015).

In the past decade, there has been an increase in total fat consumption among South Korean children, which is accompanied by a decrease in carbohydrate consumption (Sung et al., 2024). These changes are associated with shifts in school children's diets due to social and economic changes and exposure to ultra-processed foods (Sung et al., 2024). These findings

imply that school meal programs should be more adaptive to evolving consumption patterns and restore macronutrient proportions to optimal ranges.

Some findings also highlight the link between food intake and cognitive function. Fructose and fiber consumption are positively correlated with the cognitive performance of boys (Naveed et al., 2020). Meanwhile, a study in Denmark showed an improvement in reading ability in children aged 8--11 years after being given an omega-3-rich school menu (Sørensen et al., 2015). However, increased impulsivity on attention tests was also noted as a potential adverse effect of the intervention (Sørensen et al., 2015).

The results also showed a significant influence of free school meal programs on children's eating habits and social inequality. Studies in the UK and Scotland report that the Universal Infant Free School Meal policy (UIFSM) increases healthy food consumption by 25% and decreases ultra-processed food consumption by 6.8% (Parnham et al., 2024). School meals are able to increase the consumption of fruits and vegetables and reduce the consumption of ultra-processed foods, especially in children from socially vulnerable areas (Horta et al., 2019).

The behavioral aspects and preferences cannot be ignored either. Children prefer milk in plastic bottles to cardboard because of perceived fresher flavor (Sipple et al., 2021). They also favor brightly colored packaging and attractive pictures. These sensory factors have been shown to affect the level of consumption and daily nutritional fulfillment of children (Sipple et al., 2021).

Research also shows the importance of the relationship between school meals and active lifestyles. Children who are physically active consume more carbohydrates and less fat than children who are sedentary (Dunton et al., 2018). This indicates that school food consumption must be adjusted to the level of children's activity so that nutritional fulfillment is optimal. Protein administration after physical activity improves the protein balance of the child's body in the short term (Volterman et al., 2017).

Changes in consumption patterns constitute also an important finding. In South Korea, data reveal a decrease in total energy and carbohydrates, as well as an increase in the percentage of energy from fat over the past decade (2010--2020) (Sung et al., 2024). In Japan, there was a significant decrease in vitamin A, D, calcium, and iron consumption (Shinsugi & Takimoto, 2023). These studies emphasize the importance of longitudinal monitoring of school children's diets, so that trends toward micronutrient deficiencies can be addressed through early intervention.

In Canada 32.6% of a child's daily energy is consumed at school, most of it from snacks and unprepared home meals (Ziraldo et al., 2025). This shows that the school environment plays a critical role in shaping children's diets. As many as 66%--84% of children's energy in the U.S. comes from processed foods, showing a high dependence on foods low in essential nutrients (Eicher-Miller et al., 2015).

Table 2: Summary of The Ideal Composition of One Serving of Free Nutritional Meal.

Nutrition	Amount/Serving	Main Source
Energy	500–700 kcal	Rice, tubers, oil, animal fish
Protein	15–20 grams	Eggs, fish, chicken, tofu-tempeh
Total fat	20–25 grams	Vegetable oils, nuts, fish

Nutrition	Amount/Serving	Main Source
Iron	4–6 mg	Meat, liver, spinach, fortification
Calcium	300–400 mg	Milk, cheese, green vegetables
Vitamin D	5–10 µg (200–400 IU)	Oily fish, fortified milk
Fiber	5–8 grams	Vegetables, fruits, whole grains

This study synthesizes the ideal composition of seven nutritional elements in one serving of MBG in Indonesia. First, energy requirements range from 500 to 700 kcal depending on the educational level and physical activities. The proportion comprises 55-60% carbohydrates, 25-30% fat, and 15% protein (Agbozo et al., 2018; Zailani et al., 2023). Second, protein content should range from 15-20 grams per serving, with a minimum of 60% derived from animal sources (Lee et al., 2018). Third, the recommended total fat is 20--25 grams per serving and the maximum limit of saturated fat is 7--10% of the total energy. It is highly recommended that fats be obtained from vegetable oils, fish, and nuts to ensure predominantly unsaturated fat (Agbozo et al., 2018). Fourth, the ideal iron requirement is 4--6 mg per serving, with priority given to animal sources like chicken liver, red meat, or anchovies, or through fortification in flour (Agbozo et al., 2018). Fifth, the recommended calcium intake is 300-400 mg which can be obtained from milk and other dairy products or from green vegetables (Lee et al., 2018; Zailani et al., 2023). Sixth, the recommended vitamin D is at least 5--10 µg (200--400 IU) per serving, both from fortification and natural sources (Petersen et al., 2015). Seventh, the ideal fiber to consume is about 5--8 grams per serving, which comes from vegetables, fresh fruits, and whole grains such as brown rice, wheat, and corn (Zailani et al., 2023).

The results of this study show that school meal programs consistently play an important role in meeting most of the nutritional needs of school-age children. The contribution of school meals to energy needs and macronutrients such as protein, iron, and calcium can exceed 33% of the daily Nutritional Adequacy Rate of children Zailani, et al. (2023). This is reinforced by a study in Nigeria that showed the energy contribution of school meals by 16.4% to 25.5%, as well as covering more than one-third of the daily protein needs of children in rural Nigeria Ayogu, et al. (2018). These findings underscore the importance of the role of schools as institutions of not only education, but also population nutrition interventions, especially in the context of developing countries such as Indonesia.

On the other hand, some studies also show that the fulfillment of micronutrients through school meals is still a big challenge. For example, children in Sweden and Denmark are still deficient in vitamin D, iron, and fiber, despite having received free meals from the schools of Osowski et al. (2015) and Andersen et al. (2015). Supplementation of school meals with omega-3 sources such as oily fish can significantly increase vitamin D levels Al-Ghannami et al. (2016). This study provides an important implication that school meal plan not only considers the quantity of energy, but also the quality of the micronutrients it contains Al-Ghannami et al. (2016).

In addition to fulfilling nutrition, school meals have also been proven to play a role in improving children's cognitive performance. Supplemental milk protein of 8.8 grams per day to school children in Ghana can significantly improve cognitive scores and lean body mass Lee et al. (2018). These findings are supported by studies showing that increased levels of EPA and DHA from school fish consumption are positively correlated with the reading performance of children aged 8–11 years (Sørensen et al. (2015). In this context, the consumption of nutritious food in schools plays a dual role: meeting basic biological needs and strengthening the cognitive abilities that are the foundation of academic achievement.

The study also highlights the social and behavioral dimensions of school food consumption. Children from families with high social vulnerability show better dietary quality when accessing school meals regularly Horta et al. (2019). A decrease in the consumption of ultra-processed foods and an increase in the consumption of fruits and vegetables were positive impacts of the intervention. Free school meal policies in England and Scotland managed to reduce the consumption of ultra-processed foods by 6.8 percentage points, especially in the group of children from low-income families Parnham et al. (2024). Thus, the MBG program not only serves as a fulfillment of nutritional needs, but also as a social intervention to reduce inequality and inequity in access to healthy food.

Another important finding is the importance of considering children's preferences for school meals. The design of milk packaging (type of material, color, and image) significantly affects children's consumption levels Sipple et al. (2021). This shows that the success of MBG implementation is not only determined by nutritional value, but also by the level of acceptance and interest of children in the menu served. In the context of a very diverse food culture in Indonesia, this aspect is very important. The preparation of the MBG menu must pay attention to local cultural factors, family eating habits, as well as sensory and aesthetic elements so that actual consumption can be close to the ideal menu plan.

The results of this study also have high relevance to the behavioral dimensions of lifestyle and physical activity. Physically active children tend to consume more carbohydrates and less fat, while children who are more sedentary show the opposite diet Dunton et al. (2018). This shows that energy and macronutrient needs cannot be standardized in one national menu, but must pay attention to students' daily activities. The combination of MBG and physical activity education in schools is a synergistic strategy to optimize growth and prevent obesity.

In terms of public policy, this study confirms that MBG can be an important instrument in the national strategy for human resource development The free school food policy is able to increase the consumption of vegetables and fruits and reduce the intake of unhealthy foods Vik et al. (2020) and Parnham et al. (2024). The implications of these findings are huge for Indonesia, where the MBG program being designed can be a catalyst for changes in children's consumption patterns, improve national nutritional status, and save on long-term health costs.

Discussion

The significance of the results of this study lies in its ability to provide a comprehensive evaluation framework for the nutritional needs of school children in the context of the implementation of the national MBG policy in Indonesia. This study not only compiles a list of energy and nutrient needs by age group, but also synthesizes various intervention approaches, policies, and social and behavioral factors that affect the effectiveness of school

meal programs. Thus, the contribution of this research is cross-disciplinary and can be used by policy makers, nutritionists, educators, and researchers in the field of public health.

The contribution of this research to the scientific field also lies in its approach that is not only descriptive, but evaluative and applicative. This research brings together quantitative data from various countries with Indonesia's contextual perspective, so that it is able to provide more relevant and implementable policy recommendations. In addition, the integration of nutritional aspects, consumption preferences, physical activity, and public policy makes this research an important reference in the development of sustainable school-based nutrition programs.

However, this study has some limitations. First, all the data analyzed came from foreign publications, so adaptation to the Indonesian context requires further feasibility testing through local studies. Second, most studies use a cross-sectional approach or short-term experiments, so the long-term impact of school feeding interventions on children's health has not been thoroughly evaluated. Third, not all studies have measured objective nutritional status (e.g. through blood biomarkers), so conclusions still rely heavily on food intake data that have recall bias.

The implications of this research are wide-ranging, both at the policy level and in education and public health practices. In policy, the results of this research can be used as a basis for compiling national nutrition standards for the MBG program based on the age and activity of the child. Operationally, this result can help schools and education offices in designing menus that suit local needs and are accepted by children. Academically, these results may encourage follow-up research that is more contextual, longitudinal, and based on long-term impact evaluations.

In closing, this study emphasizes that MBG is not just a food assistance program, but is an evidence-based, multidimensional, and long-term oriented child nutrition development strategy. Previous research has shown that appropriately designed school feeding interventions can bring about significant changes in nutritional status, cognition, and social equity. This study confirms these findings, as well as provides a roadmap for the implementation of MBG programs in Indonesia that are contextual, adaptive, and have a broad impact on the quality development of the nation's young generation.

CONCLUSION

This systematic literature review confirms that school-based free nutritious meal (MBG) programs are a strategic intervention for meeting the nutritional needs of school-age children in Indonesia. The findings demonstrate that such meals significantly contribute to daily energy (16.4–33% of requirements), protein (over 33%), and key micronutrients like iron, calcium, and vitamin D, while also improving cognitive function, reducing ultra-processed food consumption by 6.8 percentage points, and enhancing social equity—particularly for disadvantaged children. The study provides an evidence-based framework for Indonesia’s MBG policy by integrating nutritional science, consumption behavior, physical activity, and socio-cultural contexts, aligning biological needs with public policy for sustainable human resource development. However, limitations include a reliance on short-term and cross-sectional studies, calling for longitudinal research to assess long-term impacts on nutrition, academics, and health. Future studies should prioritize localized, mixed-methods pilot projects

across Indonesia's diverse regions, incorporating biomarkers, cost-effectiveness analysis, and strategies for integrating nutrition education, community engagement, and quality assurance.

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