



What Does School-Based Nutritious Meals Program Reveal about Nutritional Status and Micronutrient Biomarkers in School-Aged Children? Implications for Indonesia's MBG Program

Asriyanti^{1*}, Rudi Saputra², Meiliati Aminyoto³

¹Medical Doctor Study Program, Faculty of Medicine, Mulawarman University, East Kalimantan, Indonesia

²Master of Public Health Study Program, Faculty of Public Health, Mulawarman University, East Kalimantan, Indonesia

³Medical Staff Group of Clinical Nutrition, Abdoel Wahab Sjahranie General Hospital, Samarinda, Indonesia

ABSTRACT

Nutritional problems among school-aged children in Indonesia continue to reflect a double burden of malnutrition, marked by the coexistence of undernutrition, overweight, and micronutrient deficiencies. In response, the Free Nutritious Meals (*Makan Bergizi Gratis*/MBG) Program was introduced as a cross-sectoral initiative that provides daily balanced meals designed to meet children's energy, protein, and essential micronutrient requirements. Existing studies consistently suggest that school feeding interventions are associated with improvements in anthropometric indicators, including weight-for-age, height-for-age, and body mass index-for-age, as well as favorable changes in micronutrient biomarkers such as hemoglobin, ferritin, and serum vitamin A. These outcomes are supported by physiological mechanisms related to adequate intake of animal-based protein, iron, zinc, and vitamin C, which are essential for growth, cognitive function, and immune competence. Nevertheless, implementation quality influences program effectiveness, including food safety, menu diversity, consistency of meal provision, and intersectoral coordination. Limited local biomarker data remain a key challenge, underscoring the need for longitudinal evaluations to assess MBG's biological impact. Overall, the MBG Program has the potential to contribute to improving the nutritional status of school-aged children and supporting Indonesia's long-term human capital development.

Keywords: Indonesia, MBG, micronutrient biomarkers, nutritional status, school-aged children.



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INTRODUCTION

Nutritional problems among school-aged children remain a significant public health challenge in Indonesia and reflect a persistent double burden of malnutrition, as undernutrition and overnutrition coexist within the same population. Recent national evidence indicates that although substantial progress has been achieved, the magnitude of childhood malnutrition remains considerable. According to the Indonesian Nutritional Status Survey (*Survei Status Gizi Indonesia/SSGI*) 2024, the national prevalence of stunting declined from 21.5% in 2023 to 19.8% in 2024; however, this figure remains substantially higher than the national development target of below 14% outlined in the national medium-term development plan.

Persistent micronutrient deficiencies further compound the problem, as approximately 16.3% of Indonesian children aged 5–14 years experience anemia, primarily associated with inadequate intake of iron-rich foods and limited dietary diversity.^{1,2}

In parallel, the country is experiencing a rapid nutrition transition, characterized by increasing consumption of ultra-processed foods, high intake of sugar-sweetened beverages, and more sedentary lifestyles among children and adolescents.^{3,4} These shifts reflect broader global dietary changes in which traditional diets are gradually replaced by more energy-dense and highly processed foods. These behavioral changes contribute to the emerging prevalence of overweight

and obesity among school-aged populations, creating a complex nutritional landscape where undernutrition, micronutrient deficiencies, and excess body weight occur simultaneously.^{1,5,6} Such conditions highlight the urgent need for comprehensive and integrated nutrition interventions capable of addressing both macronutrient insufficiency and micronutrient inadequacy during the critical developmental period of school age.^{7,8}

In response to these challenges, the Indonesian government introduced the Free Nutritious Meals Program (hereafter referred to as *Makan Bergizi Gratis*/MBG) as a national strategy to strengthen children's nutritional resilience and support long-term human capital development.⁹ The MBG

*Correspondence Author asriyanti1705@gmail.com



program provides balanced meals designed to meet children's daily requirements for energy, high-quality protein, and essential micronutrients such as iron, zinc, and vitamin A.¹⁰ The program has been gradually implemented since 2025 and represents a large-scale cross-sectoral initiative involving collaboration among the health, education, agriculture, and food security sectors. Early implementation across several provinces, including regions in eastern Indonesia, illustrates both the program's extensive potential coverage and the operational challenges arising from Indonesia's diverse geographical, infrastructural, and socio-economic contexts.^{11,12} Beyond its intended nutritional objectives, the MBG Program has the potential to improve dietary quality among school-aged children while strengthening local food systems through the use of sourced ingredients.^{10,13}

From a medical and public health perspective, school-based nutrition interventions have consistently been recognized as effective strategies for improving children's nutritional status.^{14,15} Evidence from previous intervention studies indicates that structured school feeding programs can improve anthropometric indicators, including weight-for-age, height-for-age, and body mass index-for-age, which reflect improved energy and nutrient intake during periods of rapid growth.¹⁶ In addition to anthropometric outcomes, school feeding interventions have also been associated with improvements in biochemical markers of nutritional status, including hemoglobin, ferritin, and serum vitamin A concentrations, which provide objective indicators of micronutrient adequacy at the physiological level.¹⁷ These biological improvements are typically mediated by increased intake and bioavailability of essential nutrients such as animal-based protein, iron, zinc, and vitamin C, all of which play crucial roles in erythropoiesis, immune function, cognitive development, and tissue growth.^{18,19}

However, the effectiveness of school-based feeding programs is not determined solely by nutrient provision. However, the effectiveness of school-based feeding programs is not determined solely by nutrient provision. Multiple operational factors influence the

effectiveness of school-based meal programs, including menu diversity, nutritional quality, food safety, consistency of meal provision, and children's acceptance of the meals.²⁰ In the implementation of the MBG Program, these challenges may be further compounded by large-scale food procurement and distribution, geographical disparities, limited infrastructure, and variations in local food availability.^{21,22} Recent evidence from Indonesia also highlights food safety as an important implementation concern. A qualitative study in an elementary school in West Java reported an incident involving five students who experienced nausea and abdominal discomfort after consuming milk distributed through the MBG Program, with inappropriate storage and distribution temperatures identified as contributing factors. This incident led to concerns among parents and increased demands for stronger food safety supervision.²³

In addition, a recent study among elementary and junior high school students in North Jakarta demonstrated that menu acceptability varied according to educational level and that food acceptability is an important determinant of actual consumption.²⁴ Therefore, menu design should consider sensory characteristics, dietary preferences, and students' eating habits alongside nutritional adequacy. These findings underscore the need for robust food-safety controls, appropriate storage and distribution systems, routine monitoring, and menu planning that considers students' acceptance to ensure that the nutritional benefits of MBG can be effectively realized.

Despite the rapidly expanding scale and strong policy support for the MBG Program, empirical evidence directly evaluating its biological impact on micronutrient biomarkers among Indonesian school-aged children remains limited. This evidence gap highlights the need to synthesize existing global and regional evidence to understand better the potential health effects of school-based nutrition interventions within the Indonesian context. Therefore, this literature review aims to synthesize current scientific evidence regarding the effects of school-based nutritious meal programs on children's nutritional status and micronutrient

biomarkers, while also examining their relevance for strengthening the implementation and evaluation framework of the MBG Program in Indonesia.

MAIN REVIEW

School Feeding Programs as a Nutritional Strategy for a Healthy Generation

School feeding programs are widely recognized as among the most comprehensive and sustainable community nutrition interventions globally. Beyond meeting daily energy needs, these programs function as multidimensional strategies that support optimal growth, improve nutritional status, and enhance cognitive development, school attendance, and learning outcomes.²⁵ The World Food Program describes school feeding initiatives as "a bridge between nutrition, education, and human capital development," reflecting their broad impact on physical, cognitive, social, and economic well-being.²⁶

Globally, more than 418 million children across over 176 countries benefit from school feeding programs.²⁷ Evidence consistently indicates that children who receive nutritious meals at school tend to have a lower risk of anemia, better school attendance, and improved learning performance than peers who do not participate in such programs.^{17,20} In addition to providing essential nutrients, school meals also serve as a practical platform for nutrition education, fostering healthy dietary habits early in life.

In Indonesia, these principles are reflected in the MBG Program, which provides elementary school children with one balanced, nutritious meal each school day.²⁸ The program is grounded in a nutrition-sensitive approach that positions adequate nutrition as a foundation for human development and long-term health. Through coordinated cross-sectoral efforts, MBG aims not only to reduce undernutrition but also to mitigate the risk of obesity and nutrition-related non-communicable diseases later in life.²⁹

The MBG menu emphasizes animal-based protein sources such as eggs, fish, and poultry, combined with complex carbohydrates and a variety of vegetables and fruits to ensure adequate intake of both macronutrients and



micronutrients. Meal planning follows age-specific Recommended Dietary Allowances while remaining adaptable to local food availability and cultural preferences.²⁹ This approach also supports local food systems by sourcing ingredients from nearby producers, positioning MBG as both a nutrition intervention and a community-based socio-economic initiative.

Physiologically, the school-age period (6–12 years) represents a critical window for linear growth and cognitive development, requiring sufficient energy, high-quality protein, and essential micronutrients for bone formation, muscle growth, and brain development.³⁰ Deficiencies in iron, zinc, iodine, vitamin A, and B-complex vitamins are associated with anemia, impaired concentration, reduced immune function, and delayed growth.^{17,31} Several studies have also demonstrated that balanced school meals rich in animal protein, iron, and omega-3 fatty acids are associated with better cognitive performance and memory, likely through improved metabolic stability and neurotransmission.³²

The Impact of Nutritious Meals Program on Children's Anthropometric Indicators

Anthropometric indicators such as weight-for-age (W/A), height-for-age (H/A), and body mass index-for-age (BMI/A) are widely recognized as fundamental measures for assessing children's nutritional status and growth trajectories.³³ These indicators provide objective information about both acute and chronic nutritional conditions, including underweight, stunting, and overweight. Improvements in these anthropometric parameters generally reflect adequate intake of energy, protein, and essential micronutrients required to support optimal physical growth and metabolic development during childhood. As a result, anthropometric assessment is frequently used to evaluate the effectiveness of nutrition interventions, including school-based feeding programs.^{31,34}

A growing body of evidence indicates that school-based nutritious meal programs can improve children's anthropometric outcomes. A systematic review and meta-analysis by Wang, *et al.*,³⁵ which included 19 intervention studies in low-, middle-, and high-income

countries, found that participation in school feeding programs was associated with significant increases in children's body weight and height. Specifically, children receiving school meals gained an average of about 0.58 kg and increased in height by 0.32 cm over 12 months compared with those who did not receive the intervention. These findings highlight the potential role of school feeding initiatives as effective population-based strategies to support child growth, particularly in settings where children are vulnerable to dietary inadequacy and food insecurity.

Consistent findings have also been reported in Indonesia. Dewi and Mahmudiono³⁶ demonstrated that multinutrient fortification interventions significantly improved children's height-for-age (H/A) and weight-for-age (W/A) Z-scores, indicating enhanced linear growth and overall nutritional status. The effects were particularly pronounced among children with prior energy deficiency or anemia, suggesting that nutrition interventions may produce greater benefits among nutritionally vulnerable populations. Beyond improving growth indicators, these interventions were associated with secondary benefits such as improved immune function, reduced morbidity, and lower rates of school absenteeism, further highlighting the broader health implications of improved nutrition during the school-age period.^{9,37}

Evidence from additional intervention studies also suggests that school-based nutritious meal programs can positively influence weight-for-age (W/A) and body mass index-for-age (BMI/A) indicators.¹⁶ Importantly, the observed increases in body weight are often primarily attributable to gains in fat-free mass, including muscle and bone tissue, rather than excessive fat accumulation.^{38,39} This pattern indicates that weight gain associated with school feeding programs generally reflects healthy, proportional growth rather than contributing to childhood obesity.

From a physiological perspective, these anthropometric improvements are closely related to the provision of balanced macronutrients and micronutrients that support essential biological processes during childhood development. Adequate

dietary energy and high-quality protein intake promote muscle protein synthesis, bone mineralization, and endocrine regulation of growth hormones.^{40,41} Micronutrients such as iron, zinc, iodine, and vitamins A and C also play crucial roles in erythropoiesis, immune competence, cellular differentiation, and tissue repair. Iron and vitamin C facilitate oxygen transport and iron absorption, zinc supports DNA synthesis and cell proliferation, while vitamin A contributes to immune function and epithelial integrity.^{42–44} Collectively, these nutrients support optimal growth, enhance resistance to infection, and improve overall physiological development during the critical school-age period.^{31,35}

The Role of the MBG Program in Relation to Micronutrient Biomarkers

The nutritious meals program not only improves anthropometric outcomes but is also associated with improvements in micronutrient biomarkers that reflect nutritional status at biochemical and physiological levels. Biomarkers such as hemoglobin, ferritin, serum zinc, and plasma retinol serve as objective indicators of nutrient adequacy essential for metabolism, growth, and cognitive function.^{16,17}

Globally, school-based nutrition interventions have been shown to improve micronutrient status among children. Ramaswamy, *et al.*,⁴⁵ reported a 0.44 g/dL increase in hemoglobin concentration after six months of providing iron-fortified meals. Similarly, Fungo⁴⁶ found that a school feeding program in Uganda made a substantial nutritional contribution, supplying approximately 64% of children's daily protein intake and more than 40% of their vitamin A requirements. These findings suggest that nutritious school meals contribute not only to dietary adequacy but also to correcting micronutrient deficiencies, which are key determinants of child health in many low- and middle-income settings.

From a physiological perspective, these benefits are partly explained by enhanced nutrient bioavailability resulting from balanced food combinations. The meat factor found in animal-based protein enhances iron absorption from non-heme sources, while vitamin C-rich fruits, such as oranges and papayas, can substantially increase iron



uptake. Adequate intake of zinc and vitamin A also supports DNA synthesis, immune function, and tissue repair, thereby promoting optimal growth and resistance to infection.^{32,35}

Micronutrient deficiencies, particularly those involving iron, zinc, and vitamin A, are associated with anemia, impaired immune function, and growth faltering, and often coexist within the broader context of the double burden of malnutrition. In Indonesia, approximately 16.3% of children aged 5–14 years and 15.5% of adolescents and young adults aged 15–24 years are affected by anemia, largely due to inadequate protein intake and suboptimal dietary patterns.² The MBG Program is designed to address these challenges by providing balanced daily meals that incorporate local animal-based protein sources, leafy vegetables, and vitamin C-rich fruits, which may support improvements in hemoglobin, ferritin, zinc, and retinol levels.

However, empirical studies directly assessing changes in micronutrient biomarkers following MBG implementation remain limited. This evidence gap highlights the need for longitudinal evaluations the measure of hemoglobin, ferritin, zinc, and retinol to assess the program's biological relevance. Such evidence would strengthen Indonesia's literature on school-based nutrition interventions and support the development of evidence-informed policies with potential for nationwide replication. Ultimately, the MBG Program should be viewed not merely as a social initiative but as a measurable public health investment contributing to the long-term goal of achieving Indonesia's Golden Generation 2045.

Determinants of the Effectiveness of the MBG Program

The effectiveness of the MBG Program in improving children's nutritional status depends not only on menu composition but also on implementation quality and the extent of cross-sectoral support accompanying the program. A nutrition intervention may be considered successful when it fulfills key principles, including appropriate targeting, adequate quality, consistent delivery, and long-term sustainability. Internal factors affecting program success include the quality of food ingredients, hygiene during food

preparation, frequency of consumption, and overall food safety.^{25,47}

The use of fresh and diverse ingredients, particularly locally sourced foods such as fish, eggs, poultry, vegetables, and seasonal fruits, enhances nutrient density while simultaneously supporting regional food security. Hygienic food preparation is critical, as contamination during storage or serving can reduce nutritional quality and pose health risks. Accordingly, training for school kitchen staff and regular supervision by health personnel are essential to ensure that the entire food supply chain remains safe and of high quality.²⁹ In addition, consistency in daily meal provision plays a crucial role in determining long-term outcomes. Irregular or inconsistent meal distribution may diminish cumulative effects on children's growth and micronutrient status, undermining the program's overall objectives.^{30,32}

External factors also play a pivotal role in shaping program effectiveness. Government policy support, sustainable funding mechanisms, intersectoral coordination, and active participation from communities and schools form the foundation of the MBG Program's success.^{28,48} A national evaluation by Suprpto, *et al.*,²⁸ identified several barriers to implementing school meal programs in Indonesia, including delays in food distribution, limited menu variety, and insufficient monitoring of nutritional quality. In certain regions, such as East Kalimantan, these challenges are further compounded by infrastructure limitations, geographical dispersion, and shortages of nutrition personnel and centralized community kitchens.

Given public sensitivity and ongoing debate surrounding the MBG Program, continuous monitoring, evaluation, and adaptive program improvement are essential to effective implementation. Regular evaluation enables program implementers to identify operational gaps, assess nutritional adequacy, and address concerns about food quality, acceptability, and safety. Importantly, findings from these evaluations should inform iterative program adjustments to ensure MBG remains responsive to local needs, resource availability, and emerging challenges across diverse settings.

In addition, healthcare professionals, including nutritionists and medical personnel, design and supervise the nutritional composition of each MBG menu to ensure alignment with age-specific dietary requirements and national nutrition standards. Oversight by trained health professionals is critical for safeguarding nutrient adequacy, food safety, and an appropriate balance between macronutrients and micronutrients, while preventing unintended consequences such as excessive energy intake or nutrient imbalance. This professional supervision reinforces MBG as a nutrition-sensitive public health intervention rather than merely a social assistance program. Through systematic evaluation, professional oversight, and evidence-informed refinement, the MBG Program has the potential to strengthen public trust, address existing criticisms, and enhance its effectiveness as a sustainable school-based nutrition strategy.

Within this context, a community-based approach is essential. Active involvement of healthcare workers, nutritionists, teachers, and parents is critical to ensure program sustainability and to reinforce healthy eating behaviors both at school and at home. Such collaboration strengthens nutrition education, enhances adherence to meal consumption, and increases the likelihood that interventions will produce measurable clinical and public health outcomes.

From a community medicine perspective, physicians and other healthcare professionals play a strategic role in supporting the effectiveness of the MBG Program. Monitoring biomarkers such as hemoglobin, ferritin, zinc, and vitamin A levels can serve as objective indicators of program performance. Moreover, the involvement of primary healthcare facilities and school-based health services in nutritional screening, anthropometric assessments, and family-centered nutrition education contributes to continuity of care and the long-term impact of the intervention.

The Role of the MBG Program in Improving the Nutritional Status of School Children: An Illustration from East Kalimantan

East Kalimantan exemplifies the double burden of malnutrition currently faced in several regions of Indonesia, characterized



by a high prevalence of stunting (22.2%) alongside a rising incidence of overweight (approximately 5%) among school-aged children.¹ These patterns indicate that nutritional challenges in the region may be influenced not only by food availability but also by dietary quality and access to animal-source foods. Recent evidence from East Kalimantan demonstrates that animal protein consumption is significantly associated with income structure, suggesting that economic access may influence the availability and consumption of nutrient-dense foods in the region.⁴⁹

Such trends reflect a broader nutritional transition commonly observed in areas undergoing rapid economic development and urbanization, where lifestyle changes substantially influence children's eating behaviors.⁵⁰ Within this context, the MBG Program serves as a strategic platform that integrates nutrition, public health, and education initiatives into a cohesive framework.²⁹ By providing balanced and nutritious meals on each school day, MBG has the potential to support improvements in anthropometric indicators, such as weight and height, while also contributing to better micronutrient biomarker profiles, including hemoglobin, ferritin, and serum vitamin A levels.^{32,51} When supported by a robust monitoring and evaluation system, MBG may function as a comprehensive intervention that bridges public policy, clinical practice, and community empowerment.

Furthermore, the program can serve as a school-based public health platform for systematically collecting data on nutritional status, dietary intake, and biomarker outcomes, thereby supporting research in community medicine and clinical nutrition. Given its diverse geography, encompassing both coastal and inland areas, East Kalimantan holds considerable potential as a pilot region for developing a population-based child nutrition database.

Through regular laboratory monitoring and sustained collaboration among healthcare professionals, nutritionists, teachers, and parents, MBG implementation in East Kalimantan may yield measurable benefits in preventing stunting, anemia, and childhood

obesity. If sustained over time, the program has the potential to evolve beyond a social welfare initiative into an evidence-informed national strategy to improve the nutritional quality and overall health of Indonesian children, particularly in eastern regions.

Implications for Policy, Monitoring, and Future Research

The evidence synthesized in this review highlights broader implications for developing and evaluating of school-based nutrition interventions in low- and middle-income countries. While many studies report positive associations between school meal programs and improvements in nutritional outcomes, the magnitude and consistency of these effects vary across contexts and program designs. Several evaluations indicate improvements in hemoglobin levels and reductions in anemia prevalence among participating children, suggesting that schools provide an effective platform for delivering micronutrient-rich diets and nutrition-sensitive interventions.

From a policy perspective, the findings reinforce the importance of integrating school feeding programs into broader national nutrition strategies. School-based interventions are increasingly recognized as nutrition-sensitive policies that can address dietary intake, child health, and educational participation simultaneously. Evidence from multiple countries shows that such programs may improve anthropometric indicators, dietary diversity, and micronutrient status among school-aged children. These findings suggest that national programs should be designed not only as food assistance initiatives but also as strategic public health interventions to prevent both undernutrition and micronutrient deficiencies.

Another important implication relates to the need for strong monitoring and evaluation frameworks. The literature indicates that program outcomes depend heavily on implementation quality, including meal composition, nutrient adequacy, and program coverage. Monitoring systems are therefore essential for tracking nutritional outcomes and ensuring that interventions effectively address both undernutrition and emerging risks such as overweight and obesity. Strengthening monitoring mechanisms

can also generate reliable program data to support evidence-based decision-making and continuous program improvement.

Finally, the review highlights several areas for future research. Although school-based nutrition programs are widely implemented, evidence regarding their long-term effects on growth, micronutrient biomarkers, and educational outcomes remains limited and sometimes inconsistent. Some studies report improvements in dietary intake or hemoglobin levels without significant changes in anthropometric indicators, indicating that nutritional outcomes may depend on intervention duration, dietary diversity, and contextual factors. Future studies should therefore prioritize longitudinal designs, biomarker-based nutritional assessments, and evaluations of program implementation quality to understand better the mechanisms through which school-based nutrition programs influence child health and development.

CONCLUSION

School-based nutritious meal programs represent an important public health strategy to address the multiple forms of malnutrition affecting school-aged children. Evidence from previous intervention studies and systematic reviews indicates that these programs can contribute to modest improvements in children's growth indicators, including increases in body weight and height when implemented consistently over time. Beyond physical growth, improved dietary quality through balanced school meals may also support micronutrient status and overall child health. Strengthening the evidence base on the biological and long-term outcomes of school-based nutrition programs will be essential to guide effective nutrition policies and optimize future interventions targeting school-aged populations.

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Author Contributions

Asriyanti contributed to the study conception and design, literature review, data collection, analysis, and manuscript drafting. Rudi Saputra contributed to the study design, literature review, interpretation of findings, and critical revision of



the manuscript. Meiliati Aminyoto contributed to the clinical and nutritional interpretation of the findings and critically revised the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of Interest

The authors declare no conflicts of interest.

Declaration on the Use of Artificial Intelligence (AI)

AI assistance was utilized during the preparation of this manuscript, specifically Perplexity AI for grammar checking and language refinement. AI was limited to language-related assistance and did not replace the authors' responsibility for the scientific content, interpretation, or conclusions. All authors reviewed, verified, and approved the

entire manuscript and retain full responsibility for its content.

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