

Optimizing Hazard Analysis and Critical Control Points (HACCP) Implementation in School Feeding Programs to Enhance Food Safety in LMICs: A Literature Review

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ABSTRACT

Background: School feeding programmes are among the largest nutrition and social protection interventions in low- and middle-income countries (LMICs). However, foodborne hazards remain a major challenge that may compromise programme effectiveness. As Indonesia expands its Makan Bergizi Gratis (MBG) programme, optimizing Hazard Analysis and Critical Control Point (HACCP) implementation is essential to ensure food safety. **Objective:** This literature review aimed to synthesize current evidence on HACCP implementation in school feeding programmes and identify evidence-based strategies to optimize food safety in LMICs, with implications for Indonesia's MBG programme. **Methods:** A literature review was conducted through a systematic search of the PubMed and Europe PMC databases for studies published between 2016 and 2026. The search strategy was developed using the Population, Intervention, Comparison, and Outcome (PICO) framework, and study selection followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Six eligible primary studies were synthesized narratively, while international guidelines and Indonesian policy documents were reviewed to contextualize the findings. **Results:** Three major themes were identified: behavioural factors, microbiological contamination, and institutional capacity. The evidence demonstrated that conventional food safety measures were insufficient to ensure consistent food safety performance. Optimizing HACCP implementation required

strengthening prerequisite programmes, workforce competency, continuous monitoring, systematic verification, integrated governance, and implementation fidelity. **Conclusion:** HACCP provides a comprehensive framework for improving food safety in school feeding programmes. The findings support strengthening implementation fidelity, institutional capacity, and multisectoral collaboration to ensure the safe and sustainable implementation of Indonesia's MBG programme.

Keyword : Food safety; HACCP; low- and middle-income countries; Makan Bergizi Gratis; school feeding programme

Introduction

Food safety is a fundamental component of public health and an indispensable prerequisite for achieving food security. Despite considerable progress in food production and regulatory systems, foodborne diseases remain a major global health challenge, causing an estimated 600 million illnesses and 420,000 deaths annually, with children under five years accounting for a disproportionate share of the disease burden.¹ The impact is particularly severe in low- and middle-income countries (LMICs), where inadequate sanitation, weak food safety governance, limited infrastructure, and insufficient surveillance systems increase the likelihood of food contamination throughout the food supply chain. Beyond causing acute gastrointestinal illness, unsafe food contributes to malnutrition, impaired cognitive development, reduced educational attainment, and substantial socioeconomic losses, highlighting that food safety is not merely a food production issue but an essential public health priority.¹

School feeding programmes have become one of the largest social protection and nutrition interventions worldwide, particularly in LMICs where childhood undernutrition and food insecurity remain persistent challenges.² By providing regular nutritious meals, these programmes improve school enrolment, attendance, learning capacity, dietary intake, and nutritional status while simultaneously reducing household economic burdens.^{2,3} However, the benefits of school feeding programmes can only be fully realized when meals are not only nutritionally adequate but also safe for consumption.^{1,2} Because millions of meals are prepared, transported, and distributed daily through centralized food service systems, failures at any stage of food handling may expose large numbers of children to foodborne hazards, potentially undermining the very objectives these programmes seek to achieve.^{1,4,5}

Emerging evidence indicates that food safety remains a persistent concern across

school feeding programmes in many LMICs. In Ghana, inadequate handwashing facilities, poor environmental sanitation, absence of routine health certification among food handlers, and limited food safety training were identified as major weaknesses compromising meal safety.³ Likewise, food handlers participating in South Africa's National School Nutrition Programme generally demonstrated positive attitudes toward food hygiene but exhibited important deficiencies in safe thawing practices, temperature control, and HACCP-related knowledge, indicating that awareness alone does not necessarily translate into safe food handling behaviour.⁶ Similar findings have been reported in Ethiopia, where microbiological assessment of ready-to-eat meals served through the Addis Ababa School Feeding Program detected contamination with *Escherichia coli*, *Staphylococcus aureus*, yeasts, and molds in several food samples, while a substantial proportion of drinking water samples failed to comply with microbiological safety standards.⁷ In Lesotho, microbial contamination exceeding acceptable limits was identified in milk supplied through school feeding programmes, accompanied by considerable deficiencies in food handlers' knowledge regarding milk safety, cold-chain maintenance, and contamination prevention.⁸ Collectively, these findings suggest that food safety challenges within school feeding programmes extend beyond isolated hygiene violations and instead reflect broader deficiencies in food safety management systems.

The importance of implementing comprehensive food safety systems has become increasingly relevant following the introduction of Indonesia's Free Nutritious Meals Programme (Makan Bergizi Gratis, MBG). As one of the country's largest national nutrition initiatives, MBG delivers meals to millions of beneficiaries through centralized Nutrition Fulfilment Service Units (Satuan Pelayanan Pemenuhan Gizi, SPPG). Such large-scale food production inevitably increases the complexity of maintaining food safety, making systematic risk management essential. Recognizing these challenges, the Indonesian National Nutrition Agency has incorporated food safety certification, standardized operational procedures, sanitation requirements, quality assurance mechanisms, and HACCP-based food safety management into the governance framework for SPPG to ensure that nutritional objectives are achieved without compromising food safety.^{5,10} These policy developments demonstrate Indonesia's commitment to shifting from reactive food inspection toward preventive food safety management aligned with international standards.

Therefore, this literature review aims to synthesize current evidence regarding food safety challenges, HACCP-related practices, and opportunities for optimizing HACCP

implementation within school feeding programmes in LMICs. By integrating findings from diverse settings, this review seeks to identify common barriers, implementation gaps, and evidence-based strategies that may strengthen food safety management systems while providing practical insights for supporting the safe implementation of Indonesia's Free Nutritious Meals Programme.

Methods

The Materials and Methods section must provide enough detail to enable other researchers to replicate and extend the findings of your study. It is important to note that by publishing your manuscript, you agree to make all related materials, data, computer code, and protocols accessible to readers. While new methods and protocols should be described thoroughly, established methods can be summarized briefly and cited appropriately. Names of products and manufacturers should be included only if alternate sources are deemed unsatisfactory. Novel experimental should be described in detail. If a previously established method is used, include a citation for the method and provide a brief description of it. Additionally, describe in detail any modifications you have made to the procedure. Interventionary studies involving animals or humans, and other studies that require ethical approval, must list the authority that provided approval and the corresponding ethical approval code

The method used in this study was a search of various literature sources discussing the implementation of Hazard Analysis and Critical Control Point (HACCP) in School Feeding Programs (SFPs) to improve food safety in Low- and Middle-Income Countries (LMICs). The PICO method was used to facilitate the search for literature to be used as references. The PICO framework consisted of four parts, namely Population, Intervention, Comparison, and Outcome. A combination of several terms from the PICO framework was used to search for literature relevant to this study, as follows:

- Population: School Feeding Programs (SFPs) in Low- and Middle-Income Countries (LMICs).
- Intervention: Hazard Analysis and Critical Control Point (HACCP) implementation.
- Comparison: Conventional food safety practices or food service systems without HACCP implementation.
- Outcome: Improved food safety, food hygiene, microbiological quality, and reduced foodborne contamination in school feeding programs.

Literature sources were obtained from PubMed and Europe PMC, with searches

conducted in English. Based on the type of publication, only original research articles published between 2016 and 2026 were included. The keywords used were “Hazard Analysis and Critical Control Point” OR “HACCP” AND “School Feeding Program” OR “School Meal” OR “School Food Service” AND “Food Safety” AND “Low-and Middle-Income Countries” OR “LMICs”. Keyword searches were performed using the Boolean operator method.

The data obtained from the literature search included article titles, abstracts, methods, and results. A total of 102 articles were identified from the database search. After removing 11 duplicate articles, the remaining studies were screened using predetermined inclusion and exclusion criteria. The inclusion criteria were original research articles published in English, available in full text, published between 2016 and 2026, and discussing HACCP implementation or food safety management in school feeding programs or institutional food service settings relevant to LMICs. Meanwhile, the exclusion criteria included review articles, conference proceedings, editorials, non-English publications, duplicate records, articles without accessible full text, and studies not relevant to the research objective. Finally, 6 articles met all eligibility criteria and were included in this literature review. The study selection process is presented in the PRISMA flowchart (Figure 1).

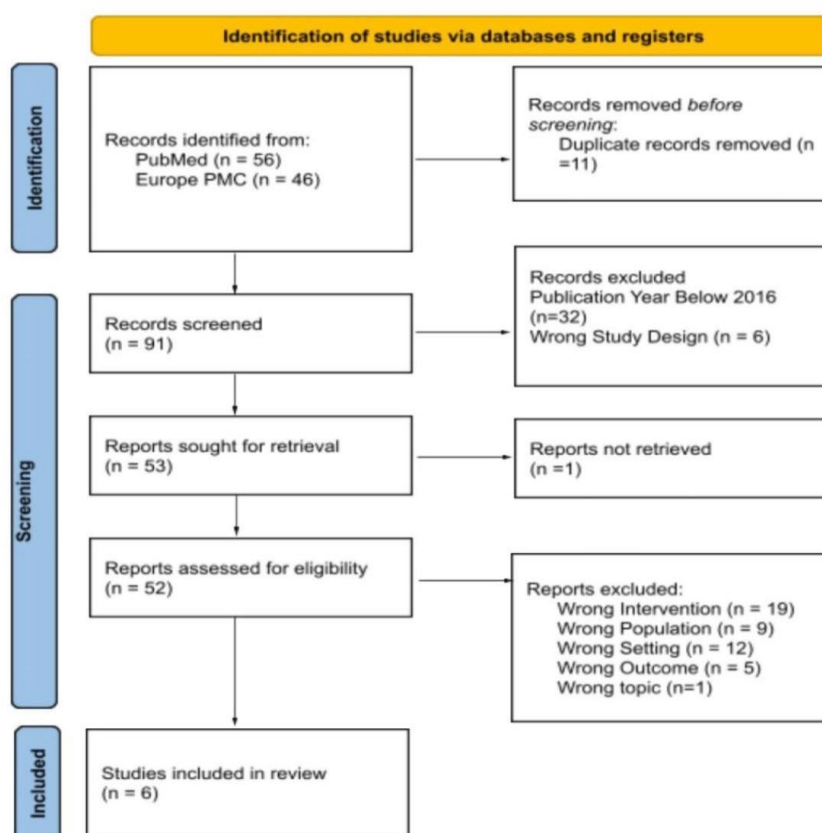


Figure 1. PRISMA Flowchart

Results

Following the screening and eligibility assessment based on the PRISMA 2020 guidelines, six primary studies met the predefined inclusion criteria and were included in the final synthesis. The included studies were published between 2020 and 2026 and represented diverse geographical settings, including Ghana, South Africa, Ethiopia, Lesotho, Brazil, and the United States. The studies employed various methodological approaches, including cross-sectional, laboratory-based, ecological, and quasi-experimental designs, to investigate different aspects of food safety in school feeding programmes. Table 1 summarizes the main characteristics of the included studies, including study design, setting, participants, key variables, principal findings, and their implications for HACCP implementation.

No	Author (Year)	Country	Study Design	Study Setting	Sample/Participants	Main Variables	Key Findings	HACCP Implications
1	Bigson et al. (2020)	Ghana	Cross-sectional	Ghana School Feeding	720 respondents (600 pupils, 60 teachers)	Food hygiene practices, sanitation	Poor handwashing practices, inadequate hygiene facilities, lack of health certificates	Strengthening prerequisite programs (GHP), mandatory food handler certification, hygiene
				Programme	60 kitchen staff from 20 schools	Food handlers	and food safety training among kitchen staff	monitoring before HACCP implementation
2	Mgqibana et al. (2020)	South Africa	Cross-sectional	Primary school feeding scheme	42 food handlers from 13 schools	Food safety knowledge, hygiene practices	Positive perception toward food safety but inadequate knowledge regarding temperature control and thawing practices; HACCP training recommended	Continuous HACCP-based training and competency assessment required to improve compliance

3	Tamiru et al. (2024)	Ethiopia	Laboratory-based cross-sectional	Addis Ababa School Feeding Program	37 ready-to-eat food samples and 18 drinking water samples	Microbiological quality	Some water exceeded microbiological standards (E. coli, S. aureus, yeasts, molds)	Food and samples	CCPs should focus on cooking, holding temperature, water quality, and environmental sanitation
4	Sello et al. (2026)	Lesotho	Cross-sectional laboratory study	Primary school feeding programme	Milk samples from 16 schools and food handlers	Milk safety, microbial contamination	Microbial contamination exceeded acceptable limits; inadequate food handlers' knowledge regarding safety and chain	Microbial contamination	HACCP monitoring should include receiving, storage, cold chain management, and food handler competency
5	Canuto et al. (2024)	Brazil	Cross-sectional ecological study	Public schools	314 public schools	Food safety performance and socioeconomic indicators	Schools in lower socioeconomic areas demonstrated poorer food safety performance, especially in food handling and temperature control	Schools in lower socioeconomic areas	HACCP implementation should be supported by adequate infrastructure and institutional capacity
6	Roberts et al. (2023)	United States	Quasi-experimental intervention	School nutrition programs	443 school nutrition employees from 21 school districts	Handwashing behaviour	Training improved behavioural intention but had limited effect on observed handwashing practices	Handwashing behaviour	HACCP implementation should integrate behavioural monitoring rather than relying solely on education

A total of six primary studies published between 2020 and 2026 met the eligibility criteria and were included in the final synthesis (Table 1). These studies were conducted in Ghana (n = 1), South Africa (n = 1), Ethiopia (n = 1), Lesotho (n = 1), Brazil (n = 1), and the United States (n = 1), representing diverse geographical and socioeconomic contexts relevant to food safety in school feeding programmes. The included studies employed a range of study designs, including cross-sectional, laboratory-based cross-sectional, ecological, and quasi-experimental approaches, providing complementary evidence on food safety practices, microbiological quality, institutional determinants, and food safety interventions.

Across the included studies, food safety was evaluated from multiple perspectives. Two studies focused primarily on food handlers' knowledge, attitudes, and hygiene practices,^{11,12} two investigated the microbiological quality of food and drinking water,^{6,7} one examined institutional and socioeconomic determinants of food safety performance,⁸ and one assessed the effectiveness of a behavioural intervention to improve hand hygiene among school nutrition employees.⁹ Despite differences in research objectives and methodologies,

the studies consistently identified recurrent challenges related to inadequate hygiene practices, insufficient food safety training, poor temperature control, microbiological contamination, and limitations in institutional capacity.

Collectively, the included studies demonstrated that food safety challenges within school feeding programmes are multifactorial, involving behavioural, environmental, and organizational factors. Several studies also highlighted that educational interventions improved food handlers' knowledge and behavioural intentions; however, sustained compliance with recommended food safety practices remained limited in the absence of adequate infrastructure, continuous monitoring, and institutional support. These recurring findings provide the basis for the thematic synthesis presented in the Discussion section, which explores their implications for optimizing HACCP implementation in school feeding programmes across LMICs.

Discussion

Understanding the Systemic Determinants of Food Safety Failures in School Feeding Programmes

The evidence synthesized in this review indicates that food safety failures in school feeding programmes should not be interpreted as isolated incidents resulting solely from individual negligence. Rather, the recurring patterns observed across LMICs suggest that these failures arise from the interaction of multiple systemic determinants involving human resources, infrastructure, institutional governance, and operational management. Although the included studies were conducted in diverse socioeconomic and geographical contexts, similar deficiencies were consistently identified, indicating that food safety challenges are driven by common structural constraints rather than country-specific conditions.^{6–8,11,12} This consistency across diverse settings suggests that improving food safety requires interventions targeting the broader food safety system instead of focusing exclusively on individual behaviour.

One of the most consistent findings across the reviewed studies is the persistent gap between food safety knowledge and actual food handling practices. Although food handlers generally demonstrated awareness of the importance of food hygiene, compliance with recommended practices remained inconsistent. Deficiencies in hand hygiene, temperature control, prevention of cross-contamination, and safe food handling practices were repeatedly reported despite generally positive perceptions regarding food safety.^{7,11,12} Likewise, Roberts et al. demonstrated that food safety training significantly improved behavioural intention but

produced only limited improvements in observed handwashing practices.⁹ These findings are highly relevant to Indonesia's Makan Bergizi Gratis (MBG) programme because large-scale meal production through SPPGs similarly requires coordinated food safety management involving competent personnel, adequate infrastructure, and effective institutional oversight. Without strengthening these systemic components, food safety risks may compromise the programme's nutritional objectives. Collectively, these findings demonstrate that knowledge acquisition alone is insufficient to produce sustained behavioural change. Instead, the effectiveness of food safety practices appears to depend on supportive organizational environments, including adequate supervision, sanitation facilities, clear operational procedures, and continuous monitoring. This observation highlights that behavioural compliance should be viewed as an outcome of the surrounding food safety system rather than solely as an individual responsibility.

The microbiological evidence further reinforces this systems perspective. Studies conducted in Ethiopia and Lesotho identified microbial contamination in ready-to-eat meals, drinking water, and milk products, including *Escherichia coli*, *Staphylococcus aureus*, yeasts, and molds, indicating that contamination may occur at multiple stages of food production and distribution.^{6,7} Because microbiological contamination represents the cumulative consequence of failures occurring during procurement, storage, preparation, cooking, transportation, and serving, these findings suggest that food safety risks cannot be attributed to a single operational error. Instead, contamination should be interpreted as evidence of weaknesses throughout the food production chain, emphasizing the importance of preventive control measures that address hazards before contaminated food reaches consumers.^{1,10}

Institutional capacity also emerged as a critical determinant of food safety performance. The Brazilian study demonstrated that schools located in socioeconomically disadvantaged regions exhibited poorer food safety performance, particularly regarding food production processes, food handler management, and temperature-controlled equipment.⁸ Similar structural limitations were identified in Ghana, where inadequate sanitation infrastructure, insufficient handwashing facilities, and the absence of regular food safety training constrained the implementation of safe food handling practices.¹¹ Taken together, these findings suggest that food safety performance is shaped not only by the competency of individual food handlers but also by the institutional capacity to provide adequate infrastructure, resources, supervision, and organizational support. Consequently, interventions directed solely at improving individual knowledge are unlikely to achieve sustainable improvements unless accompanied by broader institutional strengthening.

Overall, the available evidence demonstrates that food safety failures in school feeding programmes are primarily systemic rather than individual in nature. The recurrence of similar implementation challenges across LMICs indicates that behavioural deficiencies, microbiological contamination, infrastructure limitations, and institutional weaknesses are closely interconnected rather than independent problems. This systems perspective provides an important conceptual foundation for understanding why conventional food safety measures frequently produce inconsistent outcomes and why more integrated implementation approaches are required to strengthen food safety in school feeding programmes.

Beyond Food Handler Training: Why Conventional Food Safety Measures Remain Insufficient

The findings synthesized in this review suggest that conventional food safety measures implemented in many school feeding programmes remain insufficient to ensure consistent food safety performance. Existing interventions have predominantly emphasized improving food handlers' knowledge through periodic training, health certification, and compliance with general hygiene guidelines.^{11,12} However, the persistent recurrence of food safety deficiencies across diverse LMIC settings indicates that these interventions alone have been inadequate to prevent contamination or sustain safe food handling practices.^{6-8,11,12} This pattern suggests that conventional food safety measures frequently address individual behaviours without adequately addressing the broader organizational and operational conditions in which those behaviours occur.

One of the clearest examples of this limitation is the persistent discrepancy between knowledge acquisition and behavioural compliance. Although food handlers generally demonstrated awareness of fundamental food safety principles, deficiencies in hand hygiene, temperature control, cross-contamination prevention, and food storage practices continued to be reported.^{7,11,12} Roberts et al. further demonstrated that food safety training significantly improved behavioural intention but produced only minimal improvements in observed handwashing behaviour.⁹ Taken together, these findings indicate that educational interventions alone are unlikely to produce sustained behavioural change. Instead, translating knowledge into routine practice requires supportive organizational environments characterized by continuous supervision, adequate facilities, standardized operating procedures, and regular performance monitoring. Consequently, food safety training should be regarded as one component of a broader implementation strategy rather than as a stand-alone intervention.

The reviewed evidence also demonstrates important limitations of food safety systems that rely primarily on periodic inspections and end-product testing. Microbiological contamination identified in Ethiopia and Lesotho illustrates that unsafe food may still reach consumers despite existing food safety measures, suggesting that hazards frequently arise before routine inspections are capable of detecting them.^{6,7} Because microbiological testing is typically performed after food preparation has been completed, corrective actions implemented at this stage are inherently reactive and cannot prevent exposure among individuals who have already consumed contaminated meals. These findings emphasize that end-product inspection alone cannot effectively manage food safety risks within high-volume school feeding programmes, where prevention is considerably more effective than post-production detection.

Another recurring limitation identified across the reviewed studies is the fragmented implementation of food safety practices. Food hygiene training, sanitation monitoring, infrastructure improvements, and microbiological surveillance are frequently implemented as separate activities rather than as interconnected components of a comprehensive food safety management system. Similarly, implementation of the MBG programme should not rely solely on food handler training or periodic inspections. Continuous supervision, standardized monitoring, and consistent implementation of existing operational procedures are equally important to ensure that food safety measures are effectively translated into routine practice.^{6-8,11,12} Consequently, improvements achieved in one aspect of food safety may be undermined by deficiencies elsewhere in the food production chain. For example, appropriate cooking practices may not adequately prevent contamination when raw material handling, storage conditions, transportation, or environmental sanitation remain poorly controlled. This fragmentation reduces the overall effectiveness of food safety interventions because hazards are capable of propagating across multiple stages of food production despite compliance with selected individual procedures.

Collectively, these findings demonstrate that conventional food safety strategies remain predominantly reactive, focusing on correcting problems after hazards have emerged rather than systematically preventing their occurrence. Such approaches are particularly vulnerable within large-scale school feeding programmes, where a single operational failure may affect substantial numbers of beneficiaries. The consistent recurrence of similar implementation challenges across LMICs therefore suggests that strengthening food safety requires a transition from fragmented educational and inspection-based interventions toward integrated, preventive, and process-oriented implementation approaches capable of managing hazards

throughout the entire food production chain. This observation provides the rationale for considering HACCP implementation as a more comprehensive framework for food safety management, as discussed in the following section.

Policy Implications for Indonesia's MBG Programme

Indonesia's MBG programme has a strong regulatory foundation, with operational guidelines incorporating HACCP principles, standard procedures, and quality assurance. However, regulatory presence alone does not guarantee effectiveness. As seen in other LMICs, implementation fails due to infrastructure gaps, workforce shortages, and weak oversight. For MBG, the priority must shift from developing new regulations to ensuring implementation fidelity across all Nutrition Fulfilment Service Units (SPPG). This requires routine verification of prerequisites, competency assessments, internal HACCP audits, temperature monitoring, supplier checks, and systematic corrective action documentation.

Effective implementation further demands an integrated governance system coordinating the National Nutrition Agency, Food and Drug Authority (BPOM), local health offices, suppliers, and regional governments. Measurable indicators, regular performance evaluations, and structured feedback loops are essential. Ultimately, HACCP success in MBG should be measured by its effectiveness in consistently preventing hazards and maintaining public trust not by procedural complexity. If executed consistently, MBG can serve as a scalable public health model, simultaneously improving nutrition and protecting children from foodborne illness.

Strengths and Limitations

This review synthesizes LMIC evidence on food safety and HACCP in school feeding, linking it to Indonesian policy and MBG offering an implementation-oriented, policy-relevant contribution. Limitations include: (1) reliance on English-language, PubMed-indexed studies, potentially excluding relevant evidence; (2) considerable heterogeneity in study designs and contexts, limiting direct comparisons; (3) a limited number of primary studies specifically evaluating HACCP in school feeding settings; and (4) the absence of primary MBG implementation data, given its early stage. Therefore, recommendations are evidence-informed rather than evaluative. Future research should prioritize prospective implementation studies, fidelity assessments, and programme evaluations within LMIC national feeding programmes to strengthen the evidence base.

Conclusion

This literature review establishes that food safety challenges in LMIC school feeding programmes arise from interconnected behavioural, operational, and institutional failures including inadequate hygiene, limited handler competency, microbial contamination, poor infrastructure, fragmented management, and weak oversight which conventional training and periodic inspections alone cannot resolve. While HACCP provides a robust preventive framework through risk-based monitoring and integrated management, optimizing its implementation in LMICs demands far more than technical compliance; it necessitates strengthening implementation capacity via robust prerequisite programmes, competency-based workforce development, continuous verification, institutional governance, and multisectoral collaboration, all adapted for feasibility and sustainability rather than procedural complexity. For Indonesia's Makan Bergizi Gratis (MBG) programme, existing regulatory frameworks from the National Nutrition Agency and BPOM provide a critical foundation, yet policy effectiveness ultimately hinges on translating these standards into routine operational practice through rigorous monitoring, quality assurance, and institutional capacity building. Ultimately, optimizing HACCP should be viewed not merely as a regulatory obligation but as a strategic investment in protecting child health, sustaining public trust, and ensuring the long-term success of national school feeding initiatives across Indonesia and other LMICs.

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