

Hazard Analysis and Critical Control Points (HACCP) as a Food Safety System Recommendation Compared to Conventional Sanitation in the Free Nutritious Meal Program (MBG): A Literature Review

Diyanty Nur Hidayah Putry^{1*}, Hilmi Rakha Aryasatya¹

¹ Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur, Surabaya, Indonesia

Corresponding Author

Name : Diyant Nur Hidayah Putry
Affiliation : Faculty of Medicine, Universitas Pembangunan Nasional Veteran Jawa Timur
Address : Jl. Rungkut Madya No. 1, Gunung Anyar, Surabaya 60294, East Java, Indonesia
Email : diyantnurhidayah@gmail.com

ABSTRACT

Background: Food safety is a critical concern in structured nutrition programmes, such as Indonesia's Free Nutritious Meal Programme (MBG). Traditional hygiene practices alone may not effectively prevent food contamination, and the Hazard Analysis and Critical Control Points (HACCP) framework has been proposed as a more thorough, proactive alternative. **Objective:** This review compared HACCP with conventional sanitation practices and assessed its potential as a formal food safety framework for MBG. **Methods:** PubMed and ScienceDirect for articles published between 2020 and 2026 were searched using the PICO framework for open-access, English-language studies on HACCP and food safety in institutional catering published within the past decade. Following PRISMA-guided screening, 11 studies met all eligibility criteria and were included. **Results:** Included studies consistently found weaknesses in sanitation practices, food handlers' knowledge and behaviour, temperature control, and microbial contamination under conventional systems, while HACCP adoption improved hazard identification, compliance, hygiene monitoring, and microbial control. **Conclusion:** HACCP offers a more thorough, proactive approach than conventional sanitation alone and is recommended as MBG's core food-safety framework to reduce contamination risk and support the programme's long-term sustainability.

Keyword : Conventional sanitation; food safety management; free nutritious meal program (MBG); HACCP; institutional feeding; school feeding.

Introduction

Food safety is a major global public health concern. Foodborne illnesses contribute substantially to the worldwide burden of disease and premature death, and they disproportionately affect vulnerable groups such as children, the elderly, and individuals with weakened immune systems. Within institutional food service settings, such as school feeding programmes, hospitals, and communal catering operations, the risk of foodborne contamination is heightened by the large volumes of food that must be prepared and distributed. Improper food handling, cross-contamination between raw and cooked items, inadequate temperature control, poor personal hygiene among food handlers, and weak sanitation practices have been identified as the main contributors to illness outbreaks linked to contaminated food in these settings.^{1,4,5}

Indonesia's Programme *Makan Bergizi Gratis* (MBG), or Free Nutritious Meal Programme, is expected to improve children's nutritional status and contribute to long-term human capital development. However, the scale of food preparation, storage, and distribution required by a national programme of this size adds considerable complexity to maintaining food safety across the supply chain. Without a robust food safety oversight system, MBG kitchens remain exposed to microbiological, chemical, and physical hazards, which could compromise public health and undermine public trust in the programme.

Conventional sanitation practices, including routine cleaning and sanitising of equipment, personal hygiene, use of protective clothing, and general upkeep of the food preparation environment, remain essential components of food safety. However, evidence from the studies reviewed here suggests that these measures alone are often insufficient to prevent foodborne contamination, and need to be reinforced by structured hazard-identification procedures and ongoing monitoring.^{12,13} Several of the included studies documented gaps in food handlers' knowledge, inadequate temperature control, poor personal hygiene, improper food storage, and cross-contamination, even where basic sanitation procedures were nominally in place.^{1,11,13,14,16} This suggests that conventional sanitation, as typically practised, tends to focus on hygiene-related behaviour without a systematic mechanism for identifying and controlling hazards across the entire food preparation and distribution process.

HACCP is an internationally recognised, systematic approach to food safety management. Rather than relying on general hygiene rules, it identifies specific biological, chemical, and physical hazards at each stage of food production and designates Critical Control Points (CCPs) where these hazards can be actively monitored and controlled. A

functioning HACCP system requires defined monitoring procedures, corrective actions when limits are exceeded, verification steps, and documentation covering the process from raw material sourcing through to final service.¹² Among the studies reviewed here, familiarity with HACCP was associated with better food safety knowledge and practice scores, and a facility already operating under HACCP was able to identify, quantify, and trace the causes of specific compliance failures through its audit records, something none of the conventional-sanitation studies in this review were able to do.^{12,14}

Although a substantial body of research has examined food safety regulation, food handlers' knowledge and practices, and HACCP implementation in institutional catering settings, comparative evidence weighing HACCP directly against conventional sanitation as a food safety strategy for large-scale public nutrition programmes, such as Indonesia's MBG, remains limited. This gap is significant given that MBG, as a rapidly scaled national feeding programme, requires a food safety framework robust enough to prevent contamination across every stage of food production and distribution.

Accordingly, this literature review aimed to compare the effectiveness of HACCP with conventional sanitation practices in institutional and school-based catering settings, and to evaluate the potential applicability of HACCP as a formal food-safety management framework to support the implementation of Indonesia's MBG programme.

Methods

This study was conducted as a literature review structured in accordance with the PRISMA 2020 reporting guidelines, examining HACCP implementation as a recommended food-safety intervention relative to conventional sanitation practices. To preserve the integrity of the data synthesis, eligibility was restricted to primary empirical studies; secondary literature such as other reviews, commentaries, and opinion pieces were excluded. Eligibility criteria were further operationalized using the PICO framework: the Population comprised kitchen personnel, food operators, and managers involved in institutional or school-based feeding schemes relevant to the Free Nutritious Meal Program (MBG); the Intervention of interest was the implementation of HACCP systems; the Comparison condition consisted of conventional sanitary practices or food-safety management without a HACCP framework; and the Outcomes of interest included reductions in microbial or bacterial contamination, improved hygiene compliance, and overall gains in food-safety performance.

Two electronic databases, PubMed and ScienceDirect, were searched to identify

potentially eligible records. To capture the most current evidence on food safety and mass-catering protocols, the search was limited to publications from the past ten years that were written in English and available through open access. Search terms combined population- and setting-related keywords with food-safety and HACCP-related concepts using Boolean operators, producing the following search string applied across both databases, namely ("Food Handlers" OR "School Feeding" OR "Mass Catering" OR "Institutional Catering") AND (HACCP OR "Conventional Sanitation") AND ("Food Safety" OR "Microbial Contamination" OR "Hygiene Compliance").

Database searching yielded an initial pool of 1,090 records. During automated screening, 968 records were removed as ineligible and a further 44 were excluded for other compliance-related reasons, leaving 78 records for manual screening of titles and abstracts. This step resulted in the exclusion of 42 records considered irrelevant to the review's focus, after which 36 full-text articles were retrieved for detailed eligibility assessment. Of these, full-text assessment led to the exclusion of 25 records, comprising 14 studies involving an inappropriate population and 11 studies reporting outcomes outside the intended scope. This left 11 primary studies that satisfied all eligibility criteria and were retained for data synthesis. The complete selection process, conducted in accordance with PRISMA 2020 reporting standards, is presented in Figure 1.

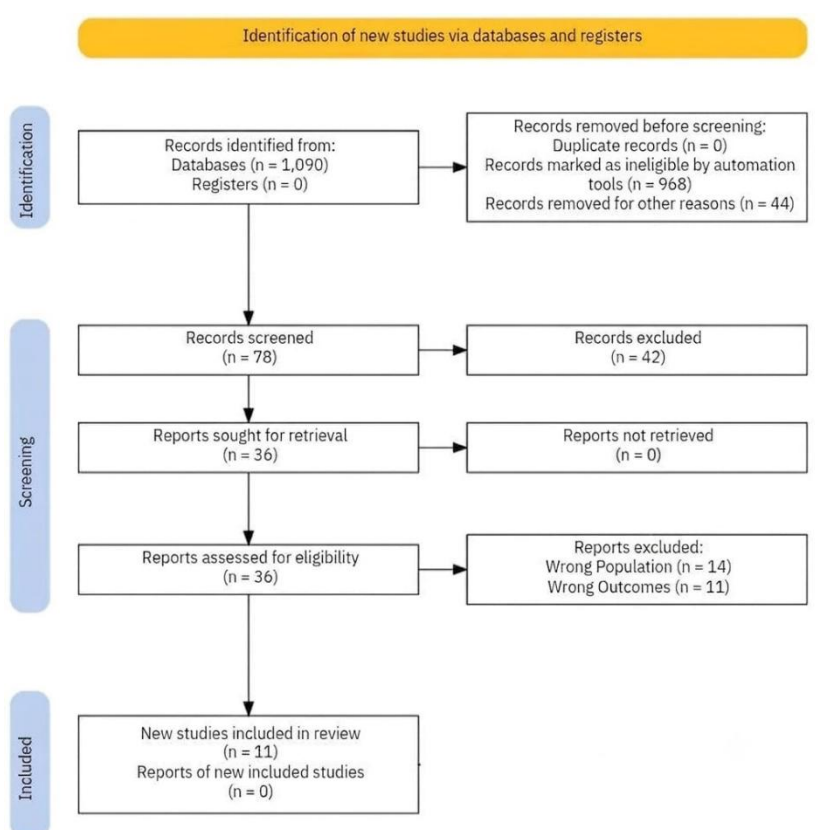


Figure 1. PRISMA Flowchart.

A standardized data extraction template was developed to capture essential variables from the 11 selected works, including the original research and article published year. The final synthesis incorporated diverse original methodologies, encompassing cross-sectional surveys, epidemiological outbreak investigations, and multi-year surveillance studies.

The extracted evidence was qualitatively synthesized through a comparative matrix framework, focusing heavily on assessing the knowledge, attitudes, and practices (KAP) of kitchen staff, structural sanitation barriers, and quantitative microbiological assessments across institutional feeding sectors. This synthesis provides an evidence-based foundation to help strengthen food safety in the Free Nutritious Meal Program.

Results

Study Selection

The systematic search of PubMed and ScienceDirect identified 1,090 records. During automated screening, 968 records were removed as ineligible and 44 were excluded for other reasons, leaving 78 records for title and abstract screening; 42 of these were subsequently excluded as irrelevant to the review's focus. Of the 36 full-text articles assessed for eligibility, 25 were excluded, comprising 14 studies involving an inappropriate population and 11 studies reporting outcomes outside the intended scope. This process, conducted in accordance with PRISMA 2020 guidelines, ultimately yielded 11 primary studies that satisfied all eligibility criteria and were retained for qualitative synthesis.

Study Characteristics

This literature review included 11 studies published between 2017 and 2026 examining food safety systems and hygiene compliance in school-based or institutional feeding programs. The study designs, populations, interventions, and principal outcomes of each included study are summarized in Table 1.

Table 1. Summary of Included Studies on Food Safety and Hygiene Compliance in Institutional Feeding Programs

No	Source	Article Title	Study Design	Population (P)	Food Safety System / Intervention Evaluated	Outcomes: Microbial Contamination & Hygiene Compliance	Key Findings
1	Bujang et al., 2023	Outbreak of foodborne disease in a boarding school, Negeri Sembilan state, Malaysia, 2021	Case-control study	Female students at a secondary boarding school.	Conventional food handling and temperature control assessment.	Suspected microbial contamination (<i>Bacillus cereus</i>) linked to poor hygiene compliance regarding temperature control and cross-contamination.	25.5% attack rate; <i>Bacillus cereus</i> outbreak linked to cross-contamination and poor temperature control.
2	Makhunga, Machereira & Hlongwana, 2023	Food handlers' knowledge, attitudes and self-reported practices regarding safe food handling in charitable food assistance programmes in the eThekweni District, South Africa: cross-sectional study	Cross-sectional study	Food handlers in charitable food assistance programmes (CFAPs).	Safe food handling practices based on WHO guidelines.	Low hygiene compliance specifically in temperature control, thorough cooking, and reheating procedures.	Good overall KAP, but severe knowledge gaps in temperature control (92.5%) and proper reheating (53%).
3	Lupattelli et al., 2023	Microbiological Safety and Quality of Meals and Work Surfaces in Collective Catering Systems in Central Italy: A Five-Year Monitoring Study	Observational study	Collective catering systems in schools and hospitals/nursing homes.	Routine catering hygiene and microbiological safety monitoring.	High hygiene compliance (low non-compliance rates) over time; <i>Campylobacter</i> spp. identified as the main microbial contaminant.	Low hygiene non-compliance (2.2-6.3%) decreasing over 5 years; <i>Campylobacter</i> spp. was the main isolated pathogen.
4	Osimani et al., 2018	Hygiene auditing in mass catering: a 4-year study in a university canteen	Observational study	A university canteen producing approximately 1,200 meals daily	Standard hygiene auditing using a comprehensive seven-item checklist.	Significant hygiene non-compliance in temperature maintenance, staff attire, and personal hygiene.	50% non-compliance in meal temperature maintenance, alongside issues in staff attire and personal hygiene.
5	Madlala et al., 2025	Metagenomic evaluation of food hygiene practices in the National School Nutrition Programme in KwaZulu Natal, South Africa	Cross-sectional study	Primary schools in the National School Nutrition Programme (NSNP).	School nutrition programme hygiene practices and environmental sanitation.	Extreme hygiene non-compliance (inadequate sanitation, no certificates); significant <i>Pseudomonas</i> contamination on hands and surfaces.	Zero schools had Acceptability Certificates; poor sanitation/pest control; high <i>Pseudomonas</i> contamination.
6	Vitória et al., 2021	Food safety knowledge, attitudes and practices of food handlers: A cross-sectional study in school kitchens in Espírito Santo, Brazil	Cross-sectional study	Food handlers in a municipal school food service network.	Routine food safety knowledge, attitudes, and practices (KAP) evaluation.	Poor hygiene compliance potential due to weak correlations between knowledge, attitudes, and actual self-reported practices.	Low knowledge scores; weak correlations between knowledge, attitudes, and reported practices.
7	Tamiru et al., 2024	Microbiological safety assessment of ready-to-eat cooked foods in the Addis Ababa School Feeding Program, Ethiopia	Cross-sectional study	Ready-to-eat (RTE) foods and drinking water in a public primary School Feeding Program.	RTE food safety and water quality microbiological assessment.	High microbial contamination limits exceeded for yeasts/molds, <i>E. coli</i> , <i>S. aureus</i> in food, and APC in water.	High limit exceedance for yeasts/molds (78.4%), <i>E. coli</i> (10.8%), <i>S. aureus</i> (5.4%) in food, and APC (72.2%) in water.

8	Abegaz, 2022	Food Safety Practices and Associated Factors in Food Operators: A Cross-Sectional Study in the Students' Cafeteria of Woldia University, North Eastern Ethiopia	Cross-sectional study	Food handlers in a university student cafeteria.	Basic food safety practices and personal hygiene evaluation.	Poor personal hygiene compliance, notably the failure to wash hands with soap after toilet use.	Only 48.8% had good practices; 52.6% didn't wash hands post-toilet; poor practices linked to lack of training.
9	Siddiky et al., 2024	Determinants of food safety knowledge and practices among food handlers in Bangladesh: An institution-based cross-sectional study	Cross-sectional study	Institutional food handlers at public universities, hospitals, and a military cantonment.	General food safety knowledge and practices assessment.	Moderate overall hygiene compliance, but high non-compliance regarding safe food thawing and pathogen awareness.	Moderate KAP; 86% improperly thawed food at room temperature; poor pathogen awareness.
10	Bigson, Essuman & Lotse, 2020	Food Hygiene Practices at the Ghana School Feeding Programme in Wa and Cape Coast Cities	Cross-sectional study	Upper-primary pupils, teachers, and kitchen staff in public schools under a feeding programme.	Food hygiene practices and structural sanitation in a school feeding programme.	Severe hygiene non-compliance due to lack of hand-washing with soap, inadequate water, and uncertified/untrained cooks.	High rates of improper hand-washing (64.6-92.2%); inadequate water supply; untrained/uncertified cooks.
11	Sibanyo ni, Tshabala & Tabit, 2017	Food safety knowledge and awareness of food handlers in school feeding programmes in Mpumalanga, South Africa	Cross-sectional study	Food handlers in the National School Nutrition Programme (NSNP) at public schools.	HACCP awareness and standard sanitation practices evaluation.	Extreme hygiene non-compliance regarding utensil sanitation and an overwhelming lack of HACCP framework implementation.	91.4% lacked HACCP programs; 93.2% unaware of HACCP; 95.5% never sanitized utensils post-use

Infrastructure and Basic Sanitation Deficiencies

Findings from the included studies point to persistent, infrastructure-level deficiencies as a foundational barrier to food safety in school feeding programs, with inadequate water access and sanitation infrastructure reported across multiple settings.^{4,9,15} An environmental assessment of primary schools participating in a national school nutrition program found that none held a valid environmental health acceptability certificate, alongside inadequate pest control and general sanitary conditions.⁹ Structural limitations were also evident in Ghana,

where school feeding program kitchens experienced an insufficient water supply and were staffed largely by uncertified, untrained cooks.⁴ These infrastructural gaps carry direct consequences for water safety: drinking water distributed through a school feeding program in Ethiopia exceeded the acceptable aerobic plate count threshold in 72.2% of samples tested, signaling substantial microbial risk at the point of consumption.¹⁵ The practical impact of such deficiencies is illustrated by an outbreak investigation in a Malaysian boarding school, where an attack rate of 25.5% was recorded among students, with suspected *Bacillus cereus* contamination traced to inadequate temperature control and cross-contamination during meal preparation.⁵ Even in a comparatively well-resourced setting, a four-year hygiene audit of a university canteen serving approximately 1,200 meals daily found non-compliance in meal-temperature maintenance in half of all observations, alongside recurrent lapses in staff attire and personal hygiene.¹² Together, these findings suggest that basic sanitation infrastructure, far from being a solved baseline, continues to represent a major and unresolved challenge across the settings reviewed.

Food Handlers' Knowledge and Behavioral Practices

A second theme emerging from the included studies is a marked disconnect between the knowledge and actual practice of food handlers, a gap documented consistently across settings regardless of overall education level.^{1,11,14,16} Although general hygiene awareness was often reasonably high, this understanding did not consistently extend to more technical, higher-risk procedures. Among institutional food handlers surveyed in Bangladesh, overall knowledge and practice were rated only moderate, and 86% reported thawing frozen food at room temperature rather than through safe methods, alongside limited awareness of common foodborne pathogens.¹⁴ A similar pattern was observed among food handlers in an Ethiopian university cafeteria, where only 48.8% demonstrated good overall practice and 52.6% reported not washing their hands with soap after using the toilet.¹ In Brazil, food handlers working within a municipal school feeding network likewise showed low overall knowledge scores that correlated only weakly with their self-reported attitudes and practices, indicating that awareness alone does not reliably predict safe behavior.¹⁶ Notably, even where general knowledge and attitudes were comparatively favorable, as reported among food handlers in South African charitable feeding programs, specific high-risk competencies were markedly deficient, with 92.5% lacking adequate knowledge of temperature control and 53% lacking knowledge of proper reheating procedures.¹¹ This knowledge-practice gap was consistently linked to the absence of formal training and certification: poor practices among Ethiopian cafeteria workers were attributed to a lack of food-safety training,¹ while in Ghana, between

64.6% and 92.2% of kitchen staff, teachers, and pupils exhibited improper handwashing technique, a pattern closely associated with the employment of untrained and uncertified cooks.⁴ Underlying much of this behavioral pattern is a near-total absence of formal food-safety systems, with 91.4% of food handlers in a South African school nutrition program reporting no HACCP implementation in their kitchens and 93.2% unaware of the HACCP concept altogether.¹³

Microbiological Quality and Contamination Risks

The cumulative consequence of these infrastructural and behavioral shortcomings is reflected in the microbiological quality of food and food-contact surfaces reported across the reviewed studies.^{5,9,13,15} Ready-to-eat meals distributed through a school feeding program in Addis Ababa exceeded permissible microbial limits for yeasts and molds in 78.4% of samples, with 10.8% and 5.4% of samples also positive for pathogenic *Escherichia coli* and *Staphylococcus aureus*, respectively.¹⁵ Contamination was not confined to food itself: metagenomic analysis of a South African school nutrition program detected considerable *Pseudomonas* contamination on both food handlers' hands and kitchen surfaces.⁹ Utensil hygiene represented a particularly acute failure point, with 95.5% of food handlers in South African feeding programs reporting that utensils were never properly sanitized after use, consistent with the near-total absence of HACCP-based control systems noted earlier.¹³ Even facilities with more established monitoring practices were not entirely free of risk: five years of continuous surveillance across collective catering systems in schools and healthcare facilities in Italy, despite a declining non-compliance trend of 2.2-6.3%, still identified *Campylobacter* species as a persistent microbial hazard.⁸ Collectively, these microbiological findings indicate that the absence of routine hazard auditing and standardized control frameworks, most notably HACCP, translates into measurable and, at times outbreak-level, contamination risk for the populations these programs are intended to serve.^{5,8,13}

Discussion

Microbiological evidence of vulnerability under conventional sanitation

Direct laboratory evidence from the reviewed studies illustrates how readily contamination establishes itself once safeguards are informal or inconsistently applied. Notably, of the four studies in this review that relied on microbiological testing or outbreak investigation rather than self-reporting, every single one detected pathogens, spoilage organisms, or unsafe water at levels exceeding accepted safety thresholds.^{5,8,9,15} In an Ethiopian school feeding programme, testing of ready-to-eat meals found that yeast and

mould counts exceeded acceptable limits in more than three-quarters of samples, while *E. coli* and *S. aureus* surpassed safe thresholds in a smaller but still concerning proportion of cases, with cooked rice consistently being the most heavily contaminated item; almost a quarter of the drinking water samples from the same schools were also non-potable.¹⁵ The consequences of such lapses are not merely theoretical. A *Bacillus cereus* outbreak traced to a Malaysian boarding school canteen affected more than a quarter of the student body after beef rendang, rice, and vermicelli were cross-contaminated and held at unsafe temperatures during thawing and storage.⁵ Metagenomic sequencing of food-contact surfaces in South African schools corroborated these risks at the microbial-community level, identifying *Pseudomonas*, *Stenotrophomonas*, *Acinetobacter*, and *Pantoea* as persistent colonisers of cutting boards and utensils, regardless of a school's checklist score.⁹ Notably, the school with the highest structural compliance (80%) in that study also displayed the most diverse bacterial community on its surfaces, indicating that passing a hygiene checklist does not, by itself, guarantee microbiological safety.⁹ Even in a well-resourced setting with five years of systematic laboratory monitoring across schools and hospitals, the authors concluded that only continuous and scheduled verification, rather than a single inspection, allows contamination trends to be detected early enough to be corrected.⁸

Food handler knowledge, attitude, and practice gaps

Beyond laboratory findings, the reviewed KAP surveys converge on a similar picture of under-prepared food handlers operating without structured oversight. In Ghana, up to 92% of pupils in one municipality did not wash their hands with soap under running water, a gap compounded by the absence of handwashing stations in most surveyed schools and by cooks who lacked health certification or recent in-service training.⁴ In Mpumalanga, South Africa, 91.4% of school kitchens had no HACCP programme, 93.2% of food handlers had never heard of the term, and 95.5% reported never sanitising cutting surfaces after handling raw meat.¹³ A comparable pattern emerged among university cafeteria staff in Ethiopia, where the single strongest correlate of unsafe practice was failure to wash hands before handling food, followed by not covering hair during cooking, inadequate temperature control of cooked food, poor hygiene of utensils and surfaces, and the absence of prior food-hygiene training.¹ In Bangladesh, institutional food handlers correctly identified common foodborne pathogens by name in fewer than one in ten cases, and thawing food at room temperature, a key risk factor for bacterial proliferation, was practised by 86% of respondents.¹⁴ Collectively, these findings show that conventional sanitation, when it relies mainly on informal habit or occasional supervision rather than a documented system of critical control

points, leaves multiple entry points for contamination unaddressed.

The knowledge-practice disconnect

A further pattern across several studies is that knowledge alone does not reliably translate into safe practice, which has direct implications for interventions that rely on training alone. Food handlers in eThekweni's charitable feeding programmes reported comparatively strong knowledge (62.8%), attitude (92.5%), and practice (80.4%) scores, yet more than half admitted to never adequately reheating cooked meals, and 92.5% did not appreciate the importance of thorough cooking and temperature control, precisely the steps most responsible for eliminating pathogens once contamination has occurred.¹¹ Statistical analysis in the same study found only a weak correlation between knowledge and attitude and between attitude and practice, with the knowledge-practice relationship reaching, at best, a moderate strength.¹¹ A similar disconnect was observed among Brazilian school food handlers, whose knowledge scores were the lowest of the three KAP domains and were not significantly correlated with self-reported practice, even though most had attended at least four training sessions.¹⁶ These findings suggest that isolated training sessions or favourable self-reported attitudes are insufficient safeguards on their own; without a system that structurally enforces and verifies specific critical steps, positive knowledge or attitude scores can coexist with unsafe behaviour at the point of food preparation.

What changes under HACCP-based verification

The comparator studies in this review, which examine settings where HACCP or a structured monitoring system is at least partially implemented, suggest that such systems narrow, though do not eliminate, these gaps. Among institutional food handlers in Bangladesh, familiarity with HACCP was independently associated with both higher food safety knowledge and better practice scores in multivariable analysis, even after adjusting for education, income, and institution type.¹⁴ A four-year audit of an Italian university canteen already operating under HACCP illustrates both the value and the limits of the system in practice: cold-holding temperatures below 10°C were the single most frequent point of non-conformity, recorded in half of all audits, and separation of raw and cooked products failed in a quarter of audits, yet the existence of a structured audit trail allowed these specific failure points to be identified, quantified, and linked to a plausible cause: new, less experienced staff hired in the final audit year.¹² This is a meaningful contrast with the conventional-sanitation settings described above, where the absence of any documentation or monitoring system meant that hazards such as improper cutting-board sanitation or unsafe reheating practices could persist for years without being formally recognised, let alone

corrected.^{4,13} The five-year Italian monitoring programme reinforces the same conclusion at a systems level, framing regular, scheduled microbiological verification of both food and environmental surfaces as the most effective available tool for the prompt evaluation of sanitary conditions, precisely because it converts food safety from a one-off inspection into a continuous, correctable process.⁸

Mapping vulnerability along the food preparation process

Synthesising the vulnerability points identified across the eleven studies, food safety risk in school and institutional feeding programmes can usefully be mapped sequentially along the journey of food from receipt to service, rather than by isolated causal branches as in a conventional fishbone diagram. As shown in Figure 2, two stages are the most consistently implicated in contamination and outbreaks across the reviewed literature: thawing/storage and final holding/serving. Improper thawing and inadequate storage temperatures were directly implicated in the Malaysian *B. cereus* outbreak⁵ and remained among the most frequent points of non-conformity even in an audited HACCP system,¹² while inadequate final holding and reheating practices were identified as major knowledge and practice gaps in South Africa¹¹ and Bangladesh.¹⁴ Mapping vulnerability onto the process flow, rather than onto a fixed set of causal categories, better reflects how HACCP itself identifies and manages risk, through critical control points located at specific stages of the process, and therefore aligns more directly with the intervention this review evaluates.

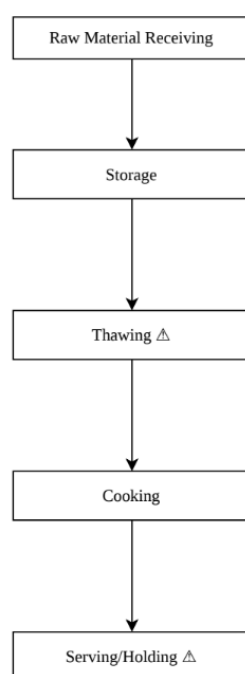


Figure 2. Process-flow diagram of food preparation stages in school/institutional feeding

programmes. Δ marks the two stages (thawing and final serving/holding) most frequently identified as vulnerability points across the studies reviewed here.

Translating this process-based mapping into actionable controls, Table 2 presents a conceptual HACCP matrix that pairs each stage of food preparation with its associated hazards, the supporting evidence identified from the reviewed studies, and recommended control measures. Rather than proposing generic hygiene rules, each measure is grounded directly in a specific failure point documented in the literature synthesised above, offering a practical starting point for translating this review's findings into an operational HACCP plan for institutional and school-based kitchens.

Table 2. Proposed conceptual HACCP matrix for school and institutional feeding programs

Process Stage	Potential Hazard	Evidence of Vulnerability from Reviewed Literature	Recommended HACCP Control Measures
Receiving & Water Supply	Microbiological contamination (High Aerobic Plate Count, <i>E. coli</i>).	72.2% of drinking water samples in a school feeding program exceeded safe APC thresholds.	Routine microbiological testing of water sources; prohibiting the use of communal washing basins.
Thawing & Storage	Pathogen proliferation (<i>B. cereus</i> , <i>Salmonella</i>) due to Temperature Danger Zone exposure.	86% of food handlers thawed frozen food at room temperature; directly linked to a 25.5% attack rate outbreak.	Mandate thawing under refrigeration (chiller) or running potable water; maintain strict cold-holding temperature logs (<10°C).
Preparation & Cooking	Cross-contamination and persistent bacterial colonization (<i>Pseudomonas</i>).	95.5% of handlers never sanitized utensils after raw meat preparation; widespread lack of proper handwashing.	Mandatory color-coded cutting boards (e.g., red for raw meat, green for vegetables); enforced handwashing protocols and hairnet usage.
Holding & Serving	Survival of spoilage organisms (yeast/mold) and pathogens due to inadequate holding temperatures.	Yeast and mold limits exceeded in 78.4% of RTE meals; 53% of handlers lacked knowledge of proper reheating.	Establish strict maximum holding times prior to consumption; enforce hot-holding temperatures and verify with calibrated thermometers.

Relevance to Indonesia's free nutritious meal programme (MBG)

None of the eleven studies included in this review were conducted in Indonesia or examined the MBG programme directly, a gap discussed further below. Real-world evidence from MBG's own rollout, however, closely mirrors the vulnerability patterns identified across the international literature synthesised here. Since the programme's launch on 6 January 2025, Indonesia's Ministry of Health has reported 445 suspected food-poisoning incidents linked to MBG meals, affecting 37,673 recipients across 210 districts/cities in 36 provinces as of 10 May 2026, of whom 2,348 required hospitalisation.⁷ Independent monitoring by the Indonesia Education Monitoring Network (*Jaringan Pemantau Pendidikan Indonesia*, JPPI) over a closely comparable period arrived at a similar cumulative total of 37,270 victims, with Central Java, East Java, and West Java the most affected provinces, lending convergent support to the scale of the problem despite the two

tallies being compiled through different methods.⁶ An academic analysis of the outbreak pattern, based on interviews with 162 food-safety surveillance officers, attributed the recurring contamination largely to cooked meals being held at room temperature for seven to eight hours before consumption, well beyond the four-hour safe window recommended by WHO, alongside kitchen staff working without complete personal protective equipment and an estimated 11,000 SPPG kitchens operating without basic sanitation certification.¹⁷ These reported failure points map directly onto the thawing/storage and final holding/serving stages identified as the most consistently vulnerable across the reviewed literature (Figure 2).

Notably, government figures indicate that only 26 of the tens of thousands of operating SPPG kitchens held HACCP certification as of late 2025, and this figure had still not meaningfully increased when reassessed roughly seven months later,^{17,3} despite *Badan Gizi Nasional* (BGN), the agency responsible for MBG, having announced in October 2025 that every SPPG kitchen would eventually be required to hold HACCP certification accredited by Indonesia's National Accreditation Committee (*Komite Akreditasi Nasional*), alongside hygiene-sanitation and halal certification.² This gap between MBG's stated food-safety ambitions and its operational reality is precisely the situation in which the HACCP-based evidence reviewed here carries the greatest practical relevance.

Research gaps

Beyond the general limitations of individual study designs discussed below, this review identifies several substantive gaps in the evidence base. First, none of the eleven included studies directly compared HACCP and conventional sanitation within the same facility or population; the comparative evidence assembled here is necessarily indirect, drawn from separate studies conducted in different countries, catering sectors, and institutional contexts, rather than from head-to-head trials. Second, no included study was conducted in Indonesia or examined a feeding programme of MBG's scale and structure, that is, a rapidly scaled, decentralised national programme reliant on thousands of newly established kitchens rather than pre-existing institutional catering infrastructure. A recent Indonesian legal-policy analysis has begun to document inconsistencies in how food-safety certification requirements are enforced across SPPG kitchens, but this literature remains focused on regulatory compliance rather than on comparing food-safety outcomes under HACCP versus conventional oversight, underscoring how little empirical, MBG-specific evidence currently exists to guide the programme.¹⁰

Third, the reviewed literature offers almost no data on the cost, workforce training

capacity, or operational feasibility of implementing HACCP across large numbers of newly established kitchens simultaneously, despite this being of direct practical relevance to MBG's continued expansion. Fourth, longitudinal evidence on HACCP's sustained performance beyond initial adoption remains limited to a single setting,¹² leaving open whether observed benefits persist as programmes scale and staff turnover increases. Finally, none of the included studies linked food-safety system type directly to child health outcomes, such as diarrhoeal disease incidence or school absenteeism, relying instead on process measures such as hygiene compliance and microbial contamination as proxies for risk. Addressing these gaps, particularly through implementation research conducted within MBG itself, would substantially strengthen the evidence base available to guide the programme's food-safety policy.

Recommendations for MBG food safety management

Drawing on both the synthesised international evidence and the emerging experience of MBG's own implementation, several practical recommendations follow. First, given that thawing/storage and final holding/serving emerged as the two most consistently implicated stages across the reviewed literature (Figure 2), and that room-temperature holding of seven to eight hours has already been documented within MBG kitchens themselves,¹⁷ initial HACCP implementation should prioritise critical control points at these two stages specifically: mandatory refrigerated or running-water thawing, calibrated cold- and hot-holding temperature logs, and a defined maximum holding time before consumption, rather than attempting comprehensive system-wide implementation immediately. Second, because knowledge alone was consistently shown not to guarantee safe practice,^{11,16} food-handler training within SPPG kitchens should be paired with mandatory certification and structural enforcement mechanisms, such as supervisor sign-off on critical steps, rather than relying on training sessions alone.

Third, rather than developing a parallel oversight system, HACCP implementation for MBG should build on the certification requirements BGN itself has already announced;² the priority is accelerating and enforcing existing policy, given that only a small share of SPPG kitchens nationwide currently hold HACCP certification,^{17,3} and resolving the regulatory inconsistencies documented in the Indonesian policy literature so that certification functions as a genuine operational safeguard rather than an administrative formality.¹⁰ Fourth, consistent with the finding that infrastructure gaps undermine food safety even where checklists are nominally satisfied,⁹ continued investment in basic water access, cold storage, and kitchen capacity, ensuring individual SPPG units are not required to exceed their

designed production volume, should be treated as a prerequisite for, rather than separate from, HACCP adoption. Finally, the Italian five-year monitoring programme included in this review demonstrates the value of routine, independent microbiological verification over one-off inspection;⁸ MBG would similarly benefit from a centralised, standardised surveillance system that reconciles reporting across government and independent monitors, enabling earlier detection of emerging risks than is currently possible when case counts are compiled retrospectively from separate sources.^{7,6}

Limitations of the evidence base

The studies included in this review vary considerably in design, ranging from outbreak investigations and laboratory-based microbiological assessments to self-reported KAP surveys, which limits direct quantitative comparison between them. Self-reported practice data in particular are acknowledged by several of the original authors as prone to social-desirability bias,^{11,16} meaning true non-compliance in conventional settings may be even higher than reported. Nonetheless, the consistency of this pattern across eleven independent studies conducted in ten different countries lends weight to the conclusion that structured, HACCP-based verification offers a more reliable safeguard for school and institutional feeding programmes than conventional sanitation practices alone.

Conclusion

This review indicates that conventional sanitation practices, while necessary, are not sufficient on their own to ensure food safety in institutional feeding programmes; the eleven studies examined consistently found gaps in food handlers' knowledge, hygiene, temperature control, and microbiological quality. HACCP offers a more structured and proactive alternative, centred on hazard identification, critical control points, verification, and documentation, and is recommended as the core food-safety framework for Indonesia's *Makan Bergizi Gratis* (MBG) programme, though the evidence remains largely observational rather than drawn from direct head-to-head trials. Realising this in practice will require complementary measures such as ongoing training, regular monitoring, adequate infrastructure, and periodic verification. The mass food-poisoning incidents already reported across MBG's SPPG network, and the wide gap between announced HACCP requirements and their actual implementation, underscore the urgency of prioritising HACCP-based control before further national scale-up

References

1. Abegaz SB. Food safety practices and associated factors in food operators: a cross-

- sectional survey in the students' cafeteria of Woldia University, North Eastern Ethiopia. *Int J Food Sci.* 2022;2022:7400089.
2. ANTARA News. BGN: seluruh SPPG harus miliki sertifikat HACCP terakreditasi KAN [Internet]. Jakarta: ANTARA; 2025 Oct 2 [cited 2026 Jul 5]. Available from: <https://www.antaranews.com/berita/5148749/bgn-seluruh-sppg-harus-miliki-sertifikat-haccp-terakreditasi-kan>
 3. Badan Gizi Nasional. BGN: 198 SPPG sudah kantongi Sertifikat Laik Higiene Sanitasi [Internet]. Jakarta: Badan Gizi Nasional; 2025 Oct 1 [cited 2026 Jul 5]. Available from: <https://bgn.go.id/news/berita/bgn-198-sppg-sudah-kantongi-sertifikat-laik-higiene-sanitasi>
 4. Bigson K, Essuman EK, Lotse CW. Food hygiene practices at the Ghana School Feeding Programme in Wa and Cape Coast cities. *J Environ Public Health.* 2020;2020:9083716.
 5. Bujang NNA, Wahil MSA, Abas SA, Amin KHAK, Zulkifli NI, Shah SM, et al. Outbreak of foodborne disease in a boarding school, Negeri Sembilan state, Malaysia, 2021. *West Pac Surveill Response J.* 2023;14(3).
 6. IDN Times. JPPI catat 37.270 korban keracunan MBG sejak Januari 2025-Mei 2026 [Internet]. 2026 Jun [cited 2026 Jul 5]. Available from: <https://www.idntimes.com/news/indonesia/jppi-catat-37-270-korban-keracunan-mbg-sejak-januari-2025-mei-2026-00-fcqw5-09484p>
 7. Kompas.com. Kemenkes catat 37.000 korban keracunan Program Makan Bergizi Gratis hingga Mei 2026 [Internet]. Jakarta: Kompas.com; 2026 May 12 [cited 2026 Jul 5]. Available from: <https://regional.kompas.com/read/2026/05/12/184946778/kemenkes-catat-37000-korban-keracunan-program-makan-bergizi-gratis-hingga>
 8. Lupattelli A, Primavilla S, Roila R, Felici A, Tinaro M. Microbiological safety and quality of meals and work surfaces in collective catering systems in central Italy: a five-year monitoring study. *Biology.* 2023;12(1):64.
 9. Madlala SS, Mchunu N, Dalasile M, Pierneef R, Reddy P. Metagenomic evaluation of food hygiene practices in the National School Nutrition Programme in KwaZulu Natal, South Africa. *Health SA Gesondheid.* 2025;30(0):a2814.
 10. Makbul M, Dharmawan A, Muhaimin. Inkonsistensi kebijakan sertifikasi keamanan pangan pada Satuan Pelayanan Pemenuhan Gizi (SPPG) dalam Program Makan Bergizi Gratis. *J Law Adm Sci.* 2026;4(1):35-51.

11. Makhunga SE, Macherera M, Hlongwana K. Food handlers' knowledge, attitudes and self-reported practices regarding safe food handling in charitable food assistance programmes in the eThekweni District, South Africa: cross-sectional study. *BMJ Open*. 2023;13(3):e065357.
12. Osimani A, Milanović V, Aquilanti L, Polverigiani S, Garofalo C, Clementi F. Hygiene auditing in mass catering: a 4-year study in a university canteen. *Public Health*. 2018;159:17-20.
13. Sibanyoni JJ, Tshabalala PA, Tabit FT. Food safety knowledge and awareness of food handlers in school feeding programmes in Mpumalanga, South Africa. *Food Control*. 2017;73:1397-1406.
14. Siddiky A, Mollick K, Aktarujjaman M, Islam F, Mamun MA, Roy N. Determinants of food safety knowledge and practices among food handlers in Bangladesh: an institution-based cross-sectional study. *Heliyon*. 2024;10(4):e25970.
15. Tamiru Y, Ayelign A, Mulugeta A, Gebremedhin S. Microbiological safety assessment of ready-to-eat cooked foods in the Addis Ababa School Feeding Program, Ethiopia. *Heliyon*. 2024;10(18):e38110.
16. Vitória AGD, Oliveira JDSC, Pereira LCDA, Faria CPD, São José JFBD. Food safety knowledge, attitudes and practices of food handlers: a cross-sectional study in school kitchens in Espírito Santo, Brazil. *BMC Public Health*. 2021;21:349.
17. Wangge G, et al. Keracunan massal pada MBG: akibat aturan keamanan pangan hanya formalitas? *The Conversation Indonesia* [Internet]. 2026 May 4 [cited 2026 Jul 5]. Available from: <https://theconversation.com/keracunan-massal-pada-mbg-akibat-aturan-keamanan-pangan-hanya-formalitas-277230>