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FOOD SAFETY IN FOOD SERVICE: CROSS-CONTAMINATION, FOOD ALLERGIES, AND BEST PRACTICES IN RISK PREVENTION

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ABSTRACT: Food safety in food service establishments is critical to public health, as operational failures can lead to outbreaks of foodborne illnesses, particularly cross-contamination, inadequate time/temperature control, and poor allergen management. Thus, the objective of this study was to synthesize recent evidence on health risks in food service establishments (buffets, delivery, and catering), with an emphasis on cross-contamination, food allergies, and preventive best practices. For this study, a review of scientific literature and regulatory documents was conducted, integrating findings from observational studies, systematic reviews/meta-analyses, and regulatory guidelines, with a focus on safety management (HACCP), training of food handlers, epidemiological surveillance, and allergen control. Evidence indicates that cross-contamination and lapses in temperature control increase the risk of microbial proliferation and outbreaks, particularly in high-volume, high-pressure operations. Structured systems, such as HACCP, combined with ongoing training, audits, and organizational culture, demonstrate improved food safety performance and reduced microbiological indicators. The expansion of delivery/catering services requires specific protocols for transportation and storage, while labeling and allergen control are essential to prevent serious incidents in vulnerable consumers.

KEYWORDS: Food safety; Cross-contamination; Food allergies; Good practices; HACCP.

INTRODUCTION

Food safety is a central pillar of contemporary public health, defined as the set of conditions and practices designed to ensure that food does not cause harm to the consumer when prepared and/or consumed

in accordance with its intended use. Scientific evidence shows that failures throughout the production chain—from primary production to final consumption—are directly associated with the occurrence of foodborne illnesses, especially in institutional food services (Lues; Van Tonder, 2017). Observational studies indicate that cross-contamination, inadequate temperature control, and poor hygiene among food handlers are among the main risk factors for the introduction and spread of pathogenic biological agents, as well as chemical and physical contaminants, reinforcing the need for systemic and preventive approaches (Hartantyo et al., 2023).

In the context of prevention, the literature indicates that the implementation of structured food safety management systems, such as Hazard Analysis and Critical Control Points (HACCP), combined with ongoing training programs for food handlers, is one of the most effective strategies for reducing the incidence of foodborne outbreaks (Levy, Hashiguchi, and Cecchini, 2022). Research shows that establishments that adopt standardized hygiene protocols, process monitoring, and periodic audits have lower microbiological loads in food and greater sanitary compliance compared to those that use only ad hoc corrective measures (Palupi et al., 2024). These findings reinforce that food safety must be understood as a continuous process of improvement, supported by institutional policies, adequate infrastructure, and an organizational culture focused on prevention.

Additionally, emerging challenges related to the expansion of delivery, catering, and out-of-home food services require adaptations to traditional health control models. Recent reviews highlight that transporta-

tion, temporary storage, and handling in outdoor environments increase the risks of microbial proliferation and food recontamination, making it essential to develop specific protocols for these settings (Ali et al., 2026). At the same time, advances in epidemiological surveillance and the use of digital tools have contributed to the early detection of patterns associated with foodborne outbreaks, enabling faster responses from health authorities (Sadilek et al., 2018). Thus, strengthening food safety in the current context requires integration among science, e, management, technology, and public policy, with a focus on protecting consumer health and reducing risks throughout the entire food chain.

METHODOLOGY

This study was conducted as a qualitative literature review with the aim of gathering, analyzing, and interpreting scientific evidence related to food safety in food service establishments, with a focus on cross-contamination, food allergies, and preventive practices. The literature search was conducted in recognized databases in the fields of health and food sciences, including PubMed, Scopus, Web of Science, and SciELO. Search terms in Portuguese and English were used, such as “food safety,” “cross-contamination,” “food allergies,” “good handling practices,” and “HACCP,” combined using Boolean operators. Publications from 2016 to 2026 were selected to include up-to-date evidence aligned with recent changes in the food sector.

After selection, the studies underwent a critical review aimed at identifying points of convergence, divergence, and gaps in the available knowledge. The extracted infor-

mation was organized into thematic categories, allowing the discussion to be structured around analytical themes. Finally, the analysis was conducted interpretatively, emphasizing not only the synthesis of the findings but also their connection to the practical context of food services. This approach allowed us to understand food safety as a dynamic process, influenced by technical, operational, and organizational factors, contributing to a more critical and applied interpretation of the available data.

Cross-contamination, food safety risks, and foodborne illnesses

Cross-contamination is recognized as one of the main mechanisms for the transmission of biological, chemical, and physical agents in food service settings, and is directly responsible for a large portion of foodborne disease outbreaks. This phenomenon occurs when pathogenic microorganisms or contaminants are transferred between foods, surfaces, utensils, or food handlers, especially in environments with high production volumes and operational pressure (Lues; Van Tonder, 2017).

Observational studies conducted in catering facilities demonstrate that inadequate practices during large-scale preparation, such as sharing utensils between raw and ready-to-eat foods, favor the spread of foodborne pathogens. Hartantyo et al. (2023) found that failures in surface sanitation and operational flow control significantly increase the risk of contamination.

The link between unsafe food-handling practices and the occurrence of foodborne illnesses has been extensively documented in empirical studies, particularly in food service settings where temperature control and

personal hygiene are often inadequate. The failure to immediately refrigerate prepared foods, the storage of perishable foods in the “danger zone” temperature range (8–60°C), and inadequate practices regarding the handling of raw and cooked foods are associated with self-reported cases of foodborne illness among food handlers and consumers (Chen et al., 2024). Furthermore, the storage of cooked food outside safe temperature conditions, the absence of adequate reheating procedures, and the lack of training on hand hygiene increase the likelihood of symptoms consistent with food poisoning, indicating that lapses in time and temperature control and the persistence of unsafe behaviors are critical determinants of health risk and facilitate microbial proliferation and the occurrence of foodborne outbreaks (Chen et al., 2024; Amaich et al., 2024; Al Zoubi et al., 2025).

In the field of public food safety policies, evidence indicates that the adoption of structured food safety management systems, such as Hazard Analysis and Critical Control Points (HACCP), combined with ongoing training programs for food handlers, contributes significantly to reducing health risks and the incidence of foodborne illnesses. Interventions based on training in food hygiene and safety promote consistent improvements in food handlers’ knowledge, attitudes, and practices, fostering greater compliance with critical hazard control and mitigation procedures throughout the production process (Insfran-Rivarola et al., 2020). Furthermore, analyses of public policies applied to food service establishments show that institutional programs integrating HACCP, systematic monitoring, and periodic inspections are associated with a reduction in microbiological indicators in

food and, consequently, a lower probability of foodborne outbreaks, provided they are effectively implemented and accompanied by continuous evaluation and supervision mechanisms (Levy; Hashiguchi; Cecchini, 2022).

Technological advances have significantly expanded the capacity for epidemiological surveillance of foodborne diseases, especially through the application of machine learning models and data mining techniques. Pioneering studies have demonstrated that algorithms capable of analyzing large volumes of digital data, such as search records, online reviews, and symptom reports, enable the early identification of patterns consistent with foodborne outbreaks, allowing for faster and more targeted interventions by health authorities and strengthening outbreak investigation and response processes (Sadilek et al., 2018; Tao et al., 2023). The integration of data from social media with machine learning methods constitutes a promising tool for near-real-time surveillance of adverse food events, functioning as an early warning system complementary to traditional notification methods, especially in scenarios of high complexity and widespread population dispersion (Salaris et al., 2025).

Food allergies, tolerance, and allergen exposure

Food allergies constitute a major public health problem, resulting from abnormal immune responses to specific food proteins. This condition is characterized by a sensitization process in which food antigens activate type 2 helper T cells (Th2), leading to the production of specific IgE that binds to receptors on mast cells and basophils, culminating in the release of inflammatory

mediators such as histamine, which trigger hypersensitivity reactions ranging from mild cutaneous manifestations to potentially fatal anaphylaxis upon re-exposure to the allergen (Wong; Freeland; Nadeau, 2016; Anvari, 2019). Additionally, environmental factors, such as diet and gut microbiota composition, modulate the immune response to food antigens, influencing both the development and severity of food allergies, highlighting the role of host-microbiota interaction in tolerance or sensitization to food proteins, the breakdown of oral tolerance, and the excessive activation of the Th2-IgE axis are central determinants in the pathogenesis of IgE-mediated allergy, involving both cells of the adaptive immune system and elements of innate immunity in the perpetuation of the allergic response (Berin, 2015; Lozano-Ojalvo, Berin, and Tordesillas, 2019).

Among the main allergenic foods are peanuts and crustaceans, such as shrimp, whose allergies are recognized as frequent causes of adverse immune reactions across different age groups, with significant variations in prevalence influenced by geographic and cultural factors, diagnostic methods, and the evaluation criteria adopted in epidemiological studies, such that global reviews indicate broad regional heterogeneity in estimates of food allergies—with average rates around 4.3% in children and adults when standardized methods are used—and identify peanuts and shellfish among the most prevalent allergens in population-based studies, highlighting that prevalence measurement depends heavily on both the diagnostic definition and the demographic characteristics of the evaluated populations, which poses significant methodological challenges for epidemiological surveillance

and the formulation of public health policies (Arens, 2025; Chen et al., 2025; Wan et al., 2024).

Accurate diagnosis of food allergies is essential for proper clinical management, as traditional diagnostic methods based solely on clinical history and sensitization tests can lead to misdiagnoses or make it impossible to distinguish between sensitization and true clinical allergy. In this regard, advances in molecular diagnostic techniques—such as *component-resolved diagnostics* (CRD), which characterizes IgE responses to specific allergenic proteins—have demonstrated a greater ability to distinguish between true and cross-sensitization, improving the accuracy and predictive value of laboratory results (Satnarine et al., 2025; Calamelli et al., 2019). Furthermore, emerging approaches that combine CRD with traditional tests, such as the measurement of protein-specific IgE and basophil activation tests, enhance diagnostic granularity, assisting clinicians in risk stratification and in designing safer therapeutic options (Venter, 2025). This integration of advanced diagnostic methods helps reduce the risk of misdiagnosis and guide more effective therapeutic decisions in the management of patients with food allergies.

The clinical management of food allergies is based on integrated strategies that include strict prevention of exposure to allergens, ongoing education of patients and their caregivers to enable early recognition of symptoms, and, in more severe cases, immediate treatment of anaphylaxis as an essential measure to reduce morbidity and mortality. International clinical guidelines emphasize the importance of developing individualized action plans, prescribing and ensuring the availability of auto-injectable epinephrine, and providing adequate trai-

ning for its use in public settings, schools, and food service establishments, considering the possibility of accidental exposure to allergens (Santos et al., 2025). Furthermore, recent updates to clinical practice guidelines reinforce that early administration of intramuscular epinephrine constitutes the first-line treatment for anaphylaxis and highlight that patient education and service readiness are critical to the effective management of severe allergic reactions (Golden et al., 2024).

In addition to the clinical management of established food allergies, scientific evidence indicates that early, controlled introduction of allergens into the diet may play a significant role in inducing immune tolerance and reducing the risk of developing future allergies. Recent studies with parents and caregivers demonstrate that evidence-based guidance—especially regarding the safe and supervised introduction of potentially allergenic foods—is associated with a lower incidence of peanut allergy in childhood, reinforcing the importance of early educational strategies and nutritional counseling (Smith et al., 2025). For example, the early introduction of peanuts, when performed appropriately and in an individualized manner, can significantly reduce the occurrence of food allergies, representing a paradigm shift in traditional avoidance recommendations and with direct implications for pediatric practice and public health policies focused on primary prevention (Rosário Filho, 2015).

Good hygiene, handling, and food safety practices

The expansion of delivery and catering services has posed new challenges to food safety, especially regarding transportation, maintaining proper temperature, and the time interval between food preparation and

consumption. International reviews indicate that failures at these critical points significantly increase the risk of microbial growth and recontamination, making the development of specific operational protocols for these services essential (Ali et al., 2026). In the Brazilian context, technical and regulatory documents produced by the National Health Surveillance Agency highlight that the lack of effective time and temperature control during the transport of ready-to-eat meals is associated with a higher incidence of sanitary non-compliance, reinforcing the need for specific regulations, continuous oversight, and standardization of procedures for delivery and catering services (Brazil, 2004).

The expansion of delivery and catering services has posed new challenges to food safety, particularly regarding transportation, maintaining proper temperature, and the time between food preparation and consumption. International reviews indicate that failures in these stages significantly increase the risk of microbial growth and recontamination, requiring the development of specific protocols for these services (Ali et al., 2026). In Brazil, studies conducted on institutional food services demonstrate that the absence of temperature control during transport is associated with higher rates of non-compliance with sanitary standards, reinforcing the need for technical regulations and oversight specifically focused on delivery and catering (Silva et al., 2019).

Studies indicate that factors such as ongoing training, qualified technical supervision, and the availability of adequate infrastructure have a positive influence on food handlers' adherence to good hygiene and food handling practices, contributing to the reduction of health risks (Chen,

2025). Evidence from Brazil corroborates these findings by demonstrating that structural limitations, insufficient e and equipment, and gaps in training processes are associated with a higher frequency of unsafe practices, while ongoing training programs and technical support promote compliance with health standards and improve hygiene and sanitation conditions in food service establishments (Ferreira et al., 2022).

The implementation of food safety management systems, such as Hazard Analysis and Critical Control Points (HACCP), has been associated with process standardization, improved food safety quality, and reduced microbiological risks (Levy; Hashiguchi; Cecchini, 2022). However, the literature highlights that the effectiveness of these systems depends directly on institutional commitment, organizational culture, and the training of the teams involved. Brazilian studies indicate that the partial or merely documentary application of HACCP limits its benefits, reinforcing the importance of integrating the system into the operational routine of establishments (Genta et al., 2008).

The integration of allergen control practices into the operational routines of food service establishments is essential for the protection of vulnerable consumers, especially individuals with potentially severe food allergies. Protocols for ingredient segregation, clear labeling, and effective communication with consumers are widely recommended to reduce the risk of accidental exposure to allergens (Penna and Palhares et al., 2025). In Brazil, technical documents and scientific studies emphasize that the absence of adequate labeling and cross-contamination pose significant risks to public health, highlighting the need for

specific educational and regulatory actions focused on the handling of allergenic foods in collective settings (Brazil, 2015).

CONCLUSION

This review demonstrates that food safety in food service establishments depends critically on the ability to prevent foreseeable events throughout operational routines. Cross-contamination remains a central mechanism for the spread of hazards, especially when flows, utensils, surfaces, and hygiene practices are inadequately controlled in high-production environments (Lues; Van Tonder, 2017; Hartantyo et al., 2023). From this perspective, prevention must be understood as an ongoing commitment, supported by standardization, internal monitoring, and shared responsibility between management and staff.

The findings also reinforce that structured management programs are more effective when implemented as a living practice within the service, rather than as a purely documentary requirement. Evidence indicates that recurring training, process monitoring, and audits contribute to greater health compliance and a reduction in microbiological indicators, provided there is institutional support, resources, and an organizational culture focused on safety (Levy; Hashiguchi; Cecchini, 2022; Palupi et al., 2024). Thus, the effectiveness of control lies in both the technique and the governance of the process.

Additionally, the expansion of delivery and catering services increases the risk associated with the time–temperature factor and the interval between preparation and consumption, necessitating specific protocols for transportation and temporary storage,

including records, verification, and clear criteria for corrective action (Ali et al., 2026). In the Brazilian context, regulatory guidelines for food services provide a basis for implementing controls on hygiene, handling, and preservation, reinforcing the importance of traceability and temperature control as essential sanitary barriers (Brazil, 2004).

Finally, the review highlights that food allergies require integration between science, clinical practice, and regulation, as minor failures—such as unreported traces and cross-contamination—can result in serious events, including anaphylaxis (Wong; Freland; Nadeau, 2016). Allergen labeling, ingredient segregation, and clear communication with consumers are not merely best practices but life-saving measures, aligned with Brazilian regulatory requirements (Brazil, 2015). It can be concluded that food safety in food service establishments is an essentially preventive field, in which management, training, infrastructure, and a culture of safety determine effective consumer protection.

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