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Sanitation and Hygiene Risk Factors Associated with Salmonella Contamination in Restaurant Foods in Makassar City: An Observational Cross-Sectional Study

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ABSTRACT

Typhoid fever is an infectious disease that remains a public health concern in Indonesia, particularly in areas with inadequate sanitation. It is caused by Salmonella typhi, which is commonly transmitted through the consumption of contaminated food or water. Makassar City, as a major culinary hub, faces significant challenges in ensuring food safety across various restaurants. This study aims to analyze environmental exposure risks in restaurant food associated with typhoid fever incidence in Makassar City by identifying pathogenic microorganisms and assessing potential sources of contamination, including water quality, food material hygiene, environmental sanitation, and food handlers' hygiene practices during food preparation and serving. This study employed an analytical observational design with a cross-sectional approach. A total of 60 restaurants were selected using purposive sampling based on location, type of business, and number of visitors. Data were analyzed using descriptive and inferential statistics (Chi-square test) to determine associations between risk factors and Salmonella sp. contamination in food. The findings revealed that environmental physical conditions ($p = 0.002$; OR = 6.25), food processing hygiene and sanitation ($p = 0.009$; OR = 4.67), food handlers' personal hygiene ($p = 0.042$; OR = 3.60), and environmental contamination risk ($p = 0.023$; OR = 3.46) were significantly associated with Salmonella contamination. Restaurants that did not meet the required standards were more likely to have contaminated food compared to those that met the criteria. Meanwhile, risk control measures were not significantly associated with contamination ($p = 0.405$; OR = 1.55). In conclusion, strengthening hygiene and sanitation practices, implementing the Hazard Analysis and Critical Control Point (HACCP) system, and enhancing risk-based sanitation supervision by health authorities are essential to reduce typhoid transmission risks in restaurant settings.

Keywords : Exposure Risk; Restaurant Food; Typhoid Fever Incidence

INTRODUCTION

Food safety is a fundamental aspect of protecting public health, particularly for vulnerable groups such as pregnant women, infants, and children whose immune systems are weaker than those of adults [1]. These groups are more susceptible to foodborne diseases, especially when the food they consume is contaminated with pathogenic microorganisms [2]. Restaurants, as providers of ready-to-eat meals, carry a high potential risk of contamination due to inadequate environmental sanitation and low adherence to hygiene standards. One of the foodborne diseases that remains a public health concern is typhoid fever, a systemic infection caused by Salmonella typhi [3]. Its transmission is strongly influenced by sanitation conditions, eating habits, personal hygiene behaviors, and improper food handling practices. In developing countries, typhoid fever remains endemic, with an estimated 21.5 million cases annually. In South Sulawesi Province, the incidence rate exceeds 2,500 cases per 100,000 population, contributing 7.3% of all hospital inpatient cases [4].

Makassar City, as a rapidly growing culinary hub, faces substantial challenges in controlling food contamination. Data from Ibnu Sina Hospital for the period 2020–2022 recorded 116 cases of typhoid fever, with the highest proportion found among adolescents and children. Meanwhile, the Makassar City Health Office reported that the Kassi-Kassi Primary Health Care area recorded the highest number of cases in 2023–2024. This situation is of particular concern given that the Central Statistics Agency (BPS) notes 567 restaurants and eateries operating in Rappocini District, increasing the risk of food contamination if not accompanied by strict hygiene and sanitation oversight. Various studies confirm that Salmonella sp., Escherichia coli, Staphylococcus aureus, and Listeria monocytogenes are among the most common pathogenic microorganisms contaminating restaurant foods [5]. Studies in Makassar City have detected Salmonella sp. contamination in chili sauce used for meatball skewers and in meatball samples. In addition to poor food handling practices, contamination can also be spread by vectors such as flies.

Various studies have shown that Salmonella sp., Escherichia coli, Staphylococcus aureus, and Listeria monocytogenes are the most commonly found pathogenic microorganisms in restaurant foods [6]. The identification of Salmonella sp. in chili sauce used for meatball skewers sold in Mamajang District, Makassar City, conducted through culture and biochemical testing, revealed that 10 samples of chili sauce were contaminated with Salmonella sp., indicating that pathogenic microorganisms are highly likely to contaminate food [7]. Another study reported that the bacteriological quality of meatball samples showed six samples testing positive for Salmonella [8].

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It is important to distinguish between Salmonella typhi and non-typhoidal Salmonella (NTS). Salmonella typhi specifically causes typhoid fever, a systemic infection, whereas non-typhoidal Salmonella species are more commonly associated with gastroenteritis. Although not all Salmonella species cause typhoid fever, their presence in food indicates fecal contamination and poor sanitation practices, which are also the primary transmission pathways of S. typhi. Therefore, the detection of Salmonella sp. in restaurant food can be used as a valid proxy indicator to assess contamination risk and potential exposure pathways related to typhoid fever in the population.

Food handlers' behavior plays a central role in maintaining food quality and safety. Consumers who rely on commercially prepared foods have no control over the preparation process and thus depend heavily on the hygiene practices of food handlers [9]. Non-compliance with hygiene standards such as failure to wash hands, the use of unhygienic utensils, and improper handling of raw and cooked ingredients can significantly increase contamination risk. Several studies also show that consuming raw vegetables, poor handwashing practices, and choosing eating establishments that do not meet hygiene standards contribute to the risk of typhoid fever.

The increasing number of restaurants in Makassar, combined with the rising incidence of typhoid fever reported by local health facilities, underscores the urgent need to strengthen food safety monitoring. Vulnerable populations including pregnant women, infants, and children face heightened risks of severe complications from *Salmonella typhi* infection. As the culinary industry continues to expand, the probability of exposure to contaminated food also increases, especially when environmental sanitation, food handling practices, and hygiene compliance are suboptimal. Without effective interventions, the persistence of poor sanitation and improper food handling could exacerbate foodborne disease transmission in densely populated urban areas.

Although studies on foodborne pathogens and typhoid fever have been conducted in various settings, several critical gaps remain. First, existing research in Makassar predominantly focuses on specific food items such as meatballs or chili sauce, with limited assessment of contamination across diverse restaurant types. Second, most studies have not incorporated a comprehensive environmental exposure analysis that simultaneously examines physical environmental conditions, food handling behaviors, hygiene practices, and potential contamination sources. Third, few studies have linked microbiological findings with environmental risk factors to understand their combined contribution to typhoid fever transmission. Fourth, the majority of previous studies have not specifically highlighted the implications of contamination for vulnerable populations, despite their higher susceptibility. These gaps indicate the need for research that integrates environmental sanitation assessment, food hygiene evaluation, and microbiological testing across a broad range of restaurant settings.

Salmonella typhi infection poses serious health consequences, especially for vulnerable groups. In pregnant women, infection can lead to preterm labor, low birth weight, or miscarriage. Infants and young children, whose immune systems are not fully developed, face a higher risk of complications such as severe dehydration, intestinal perforation, prolonged fever, and impaired growth. These complications highlight the urgent need for strong food safety measures and risk mitigation strategies, particularly in rapidly urbanizing areas where the demand for ready-to-eat meals continues to increase.

Given the rapid expansion of Makassar's culinary industry and the identified research gaps, conducting a comprehensive analysis of environmental exposure risks associated with restaurant foods is essential. Such an analysis will help identify key factors contributing to food contamination and the transmission of typhoid fever. Furthermore, understanding contamination sources, exposure pathways, food handling behaviors, and sanitation practices in restaurants is crucial for developing targeted interventions. Strengthening the enforcement of food safety regulations, promoting Hazard Analysis and Critical Control Point (HACCP) implementation, improving food handler education, and increasing environmental sanitation surveillance are essential steps to reduce contamination risks. These measures will significantly contribute to improving food safety management, reducing the incidence of typhoid fever, and protecting vulnerable populations particularly mothers, infants, and children from preventable foodborne health risks.

MATERIAL AND METHOD

This study employed a quantitative approach with an analytical observational design using a cross-sectional framework. The research aimed to examine the association between environmental and hygiene-related factors in restaurants and the presence of Salmonella contamination in ready-to-eat foods. Observations were conducted directly at food preparation sites, and food samples were collected for laboratory examination. The study was conducted in restaurants located in urban areas representing diverse types of food service establishments. Field observations and food sampling were carried out on site, while microbiological analyses were performed at the Microbiology Laboratory of the Department of Environmental Health, Health Polytechnic of Makassar. The laboratory was selected because it is equipped with facilities suitable for molecular detection of foodborne pathogens, particularly Salmonella.

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The study population consisted of restaurants located in urban areas that serve a wide range of food types to consumers. A purposive stratified random sampling technique was applied, in which restaurants were first selected based on predefined inclusion criteria (such as active operation, food preparation on-site, and willingness to participate), and subsequently stratified to ensure proportional representation across different types of food service establishments. Stratification was based on factors relevant to microbiological contamination risk, including business scale, food processing systems, and serving environments. Restaurant categories followed Aisha and Bachtiar (2021), namely: (1) fine-dining restaurants, (2) fast-food restaurants, (3) local eateries, (4) cafés, (5) food stalls, and (6) street vendors. From each category, ten restaurants were randomly selected, yielding a total sample of 60 restaurants. The sample size was determined by balancing adequate representation across categories, feasibility of laboratory examination, and efficiency in terms of time and available resources.

Food samples were homogenized, and bacterial DNA was extracted and amplified using polymerase chain reaction (PCR) targeting Salmonella-specific genes, particularly the invA gene, which is widely recognized as a reliable molecular marker for the detection of Salmonella spp. Positive and negative controls were included for quality assurance, and results were classified as positive or negative for Salmonella contamination. All collected data were entered and processed electronically. Univariate analysis was performed to describe each study variable, producing frequency distributions and summary characteristics. Bivariate analysis was conducted using the Chi-Square test to determine associations between risk factors and Salmonella contamination, with a significance level of $p \leq 0.05$. Findings were interpreted in relation to food safety standards and best-practice hygiene guidelines.

RESULT

The study was conducted from July to November 2025 over a period of eight days at restaurants located within the working area of Kassi-Kassi Public Health Center, Rappocini District, Makassar City. This research employed a quantitative approach using a descriptive observational design. The study involved the collection of food samples and direct observation of potential sources of food contamination, followed by laboratory analysis to identify the presence of pathogenic microorganisms in restaurant foods. Food sampling was carried out aseptically in accordance with standard microbiological sampling procedures. The samples collected consisted of ready-to-eat foods served to customers.

Table 1. Characteristics of Food Handlers

Characteristics of Respondents	n	Percentage (%)
Age		
19-25 Years	35	58,4
25-50 Years	20	33,3
>50 Years	5	8,3
Education		
No Schooling	15	25
Primary School	12	20
Junior High School	10	16,7
Senior High School	20	33,3
Higher Education	3	5
Total	**60**	**100%**

Table 1 presents the research findings, showing that the majority of food handlers were in the productive age group of 19–25 years, totaling 35 individuals (58.4%), followed by those aged 25–50 years with 20 individuals (33.3%), and a small proportion over 50 years old (8.3%). This indicates that most food handlers are young and physically active, but this age group often lacks adequate experience and training related to food sanitation principles. In terms of education level, most respondents had completed senior high school or vocational school (33.3%), followed by those with no formal education (25%), elementary school (20%), junior high school (16.7%), and higher education (5%). The relatively low educational background of some food handlers may influence their understanding of proper hygiene and food sanitation practices. Therefore, educational interventions are essential to enhance awareness and skills in implementing safe food sanitation.

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Table 2. Univariate Analysis of Environmental Exposure Risk Variables on Restaurant Foods Related to Typhoid Fever Incidence

Research Variables	n	Percentage (%)
Environmental Physical Conditions		
Meets The Criteria	20	33.3
Does Not Meet The Criteria	40	66.7
Food Processing Hygiene and Sanitation		
Meets The Criteria	18	30
Does Not Meet The Criteria	42	70
Food Handlers Personal Hygiene		
Meets The Criteria	16	26.7
Does Not Meet The Criteria	44	73.3
Environmental Contamination Risk		
Meets The Criteria	23	25
Does Not Meet The Criteria	37	75
Risk Control Measures		
Meets The Criteria	28	46.7
Does Not Meet The Criteria	32	53.3
Total	**60**	**100**

Table 2 shows that most environmental variables in restaurants did not meet health standards. A total of 66.7% of the physical environmental conditions were classified as not meeting the requirements, indicating issues such as inadequate ventilation, poor lighting, and insufficient cleanliness of floors and walls. Regarding food processing hygiene and sanitation, 70% did not meet the standards, reflecting poor implementation of sanitation principles such as improper washing of raw ingredients, lack of separation between raw and cooked foods, and inadequate waste management. Furthermore, the food handlers' personal hygiene also showed concerning results, with 73.3% not meeting the requirements. This suggests that behaviors such as not washing hands before handling food, not using personal protective equipment (gloves, aprons, masks), and poor nail hygiene remain major challenges in preventing microbiological contamination. Environmental contamination risk was also high, with 75% of restaurants categorized as not meeting the requirements due to issues such as unclean surroundings, open trash bins, and the presence of insects or rodents near food processing areas. Meanwhile, risk control measures performed relatively better, with 46.7% meeting the standards; however, more than half (53.3%) still had suboptimal implementation, indicating inconsistencies in food safety management.

Table 3. Results of Salmonella Contamination Examination in Restaurant Food Samples

Restaurant Category	Total Samples	Positive (n, %)	Negative (n, %)
Fine-dining	10	2 (20%)	8 (80%)
Fast-food	10	4 (40%)	6 (60%)
Local eateries	10	7 (70%)	3 (30%)
Cafés	10	5 (50%)	5 (50%)
Food stalls	10	7 (70%)	3 (30%)
Street vendors	10	8 (80%)	2 (20%)
Total	**60**	**33 (55%)**	**27 (45%)**

Table 3 presents a summary of Salmonella sp. contamination in food samples based on restaurant category. Overall, 33 out of 60 samples (55%) tested positive for Salmonella sp., indicating that more than half of the sampled food establishments did not meet food safety standards. Contamination was predominantly observed in lower-tier food service establishments, particularly street vendors (80%), food stalls (70%), and local eateries (70%). In contrast, fine-dining restaurants showed the lowest contamination rate (20%), followed by fast-food restaurants (40%) and cafés (50%). This pattern suggests that the level of hygiene practices, sanitation facilities, and food handling systems varies significantly across restaurant categories. Establishments with more structured food safety management systems, such as fine-dining restaurants, tend to have better compliance with hygiene standards. Meanwhile, informal sectors such as street vendors and food stalls often operate with open food preparation systems, limited sanitation infrastructure, and lower adherence to hygiene practices, increasing the risk of contamination. These findings highlight that environmental sanitation, food handling practices, and food handlers' behavior are key determinants of Salmonella contamination in restaurant food.

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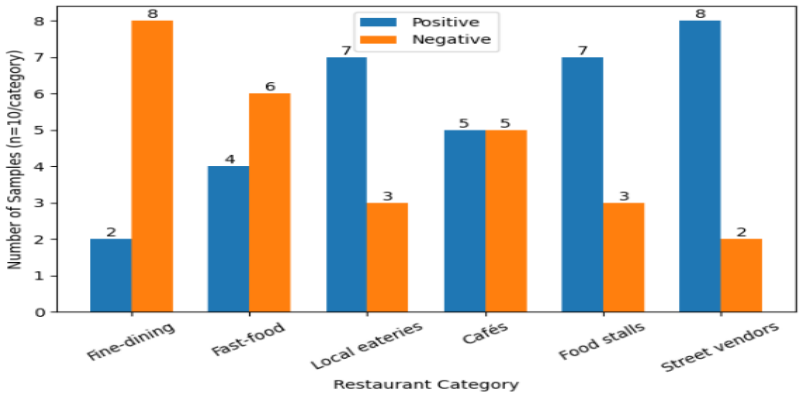

Figure 2. Salmonella Contamination Results by Restaurant Category

The graph shows the distribution of Salmonella test results based on six restaurant categories, each consisting of 10 units. Overall, food stalls and street vendors had the highest proportion of Salmonella-positive samples, followed by local eateries. These three categories generally have open processing areas, limited sanitation facilities, and inconsistent equipment hygiene controls. In contrast, the fine dining and fast food categories show lower contamination rates, likely due to the implementation of standard procedures, routine monitoring, and more structured food safety systems. The cafés category falls in the middle, with variations in food processing practices between units. This pattern confirms that differences in sanitation facilities and food handler hygiene practices between restaurant types contribute to the risk of Salmonella contamination.

Table 4. Bivariate Analysis of Research Variables and Salmonella Contamination in Restaurant Food Samples

Variable	Category	Positive n (%)	Negative n (%)	Total n (%)	p-value	OR	95% CI
Environmental Physical Conditions	MC	27 (84.4)	5 (15.6)	32 (100)	0.002	6.25	1.86–20.83
	DNMC	13 (46.4)	15 (53.6)	28 (100)			
Food Processing Hygiene and Sanitation	MC	27 (84.4)	5 (15.6)	32 (100)	0.009	4.67	1.40–15.63
	DNMC	15 (53.6)	13 (46.4)	28 (100)			
Food Handlers Personal Hygiene	MC	20 (62.5)	12 (37.5)	32 (100)	0.042	3.60	1.003–12.919
	DNMC	24 (85.7)	4 (14.3)	28 (100)			
Environmental Contamination Risk	MC	24 (75.0)	8 (25.0)	32 (100)	0.023	3.46	1.16–10.31
	DNMC	13 (46.4)	15 (53.6)	28 (100)			
Risk Control Measures	MC	16 (50.0)	16 (50.0)	32 (100)	0.405	1.55	0.55–4.31
	DNMC	11 (39.3)	17 (60.7)	28 (100)			

Table 4 shows the relationship between several environmental and hygiene-related factors and Salmonella contamination in restaurant food samples. The results indicate that most of the studied variables have a significant association with contamination. Restaurants with poor environmental physical conditions were found to have a higher risk of Salmonella contamination compared to those that met the required standards ($p = 0.002$; OR = 6.25). This means that inadequate environmental conditions can increase the likelihood of contamination. Similarly, poor food processing hygiene and sanitation were also associated with a higher risk of contamination ($p = 0.009$; OR = 4.67). Restaurants that did not follow proper hygiene practices during food preparation were more likely to have contaminated food. Food handlers' personal hygiene showed a significant relationship as well ($p = 0.042$; OR = 3.60). This suggests that poor personal hygiene among food handlers increases the risk of Salmonella contamination. In addition, environmental contamination risk was significantly related to the presence of Salmonella ($p = 0.023$; OR = 3.46), indicating that environments with higher contamination risk tend to contribute to unsafe food conditions. However, risk control measures did not show a significant relationship with contamination ($p = 0.405$; OR = 1.55), suggesting that existing control efforts were not consistently applied or effective enough to reduce the risk. Overall, these findings suggest that poor environmental conditions, inadequate hygiene practices, and higher contamination risk play an important role in increasing the likelihood of Salmonella contamination in restaurant food.

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DISCUSSION

This study was conducted from July to November 2025 in restaurants within the working area of Kassi-Kassi Public Health Center, Rappocini District, Makassar City. All activities were carried out over eight effective days using a quantitative descriptive observational approach. The primary focus of the study was to analyze the environmental exposure risks associated with restaurant foods and their relationship with typhoid fever incidence through an assessment of sanitation and hygiene conditions, food handlers' behavior, and microbiological examinations of food samples. Importantly, this study assessed contamination at the genus level (Salmonella sp.), and not specifically Salmonella typhi, therefore findings should be interpreted as indicators of general foodborne contamination risk rather than direct evidence of typhoid fever incidence.

The results indicate that most food handlers belong to the productive age group of 19–25 years (58.4%), followed by the 25–50 years group (33.3%), and those above 50 years (8.3%). These findings suggest that young workers dominate the food processing sector in Makassar, particularly in restaurants and small eateries. Although younger workers generally possess high physical capacity, their experience and understanding of food sanitation principles tend to be limited. Young workers often lack adequate food safety skills due to insufficient formal training and workplace supervision [10]. In terms of education, the majority of food handlers completed senior high school/vocational school (33.3%), while 25% had no schooling, and 20% completed only elementary school. Low education levels may affect sanitation literacy and hygienic behavior. Limited educational attainment is closely linked to inadequate knowledge of safe food management practices, including handwashing, proper food storage, and cross-contamination prevention[11]. These findings highlight the need for enhanced food hygiene and sanitation training, particularly for workers in informal food sectors such as small eateries and street vendors, which carry a higher risk of microbiological contamination [12].

Univariate analysis shows that 66.7% of the physical environment conditions in restaurants did not meet health standards, including ventilation, lighting, floor cleanliness, and wall maintenance. Inadequate physical environments increase the potential for pathogenic microorganisms to grow due to poor air circulation and high humidity. Damp, poorly lit, and poorly ventilated food preparation areas elevate the risk of contamination by Salmonella and Escherichia coli in ready-to-eat foods [13]. Additionally, 70% of hygiene and sanitation food-processing practices did not meet standards, indicating weak adherence to basic sanitation principles such as washing raw ingredients, separating raw and cooked foods, and using clean utensils. This suggests that most food handlers do not follow Standard Operating Procedures in food processing [14]. According to Indonesian Ministry of Health Regulation No. 1096/2011 on Catering Sanitation Hygiene, every food establishment must have facilities and procedures that ensure food safety. Non-compliance with these standards may be a major factor contributing to microbiological contamination [15].

The findings show that 73.3% of food handlers did not meet personal hygiene requirements. Critical behaviors observed at the research sites included: failure to wash hands before food preparation, not using personal protective equipment (PPE) such as gloves, aprons, and masks, and poor nail hygiene (long, dirty, or untrimmed nails). These conditions demonstrate that personal hygiene remains a major vulnerability in the transmission of pathogenic bacteria within food service operations. Inadequate personal hygiene greatly increases the risk of cross-contamination, either from handlers' hands to raw materials or from raw materials to cooked foods. It should be emphasized that contamination detected in this study refers to *Salmonella sp.* in general, and not specifically *Salmonella typhi*. Therefore, while poor hygiene increases the risk of bacterial contamination, it cannot be directly concluded that it increases typhoid fever incidence without further serotyping confirmation.

A study on Knowledge, Attitudes, and Practices of Hygiene and Sanitation Implementation among food handlers (2020) found that although 65.4% of handlers had adequate knowledge, only 52% practiced proper hygiene and sanitation, with mask use, gloves, and aprons identified as the weakest elements [16]. These findings align with the results of this study, reinforcing that personal hygiene is a key risk factor contributing to food contamination. Theoretically, poor personal hygiene behavior is influenced by: (1) low knowledge and understanding of microbiological contamination risks, (2) lack of formal training, (3) inadequate workplace facilities (such as handwashing stations with soap and running water, gloves, and aprons), and (4) insufficient supervision from management or regulatory agencies. For instance, a study in Boyolali reported that knowledge (OR = 7.79) and attitude (OR = 6.55) had significant associations with personal hygiene behavior among food handlers [17]. The present study's results also align with research showing that poor food handler hygiene is significantly associated with *Salmonella* contamination in ready-to-eat foods sold in eateries [18]. Human hands are the main transmission medium for pathogenic bacteria such as *Salmonella Typhi*, especially when food is handled directly without gloves. A study titled *Determinants of Personal Hygiene Behavior Among Food Handlers in Fast-Food Restaurants in South Jakarta, Indonesia* (2025) found that adequate handwashing facilities and proper work uniforms were significantly correlated with good hygiene behavior (adjOR = 6.64 and 8.48) [19].

The results show that 75% of restaurants in this study did not meet environmental contamination risk standards, with critical conditions such as uncovered trash bins, improper liquid waste disposal, and the presence of insects and rodents found in food preparation areas. Such unhygienic physical environments are important contributors to the spread of pathogenic bacteria and facilitate cross-contamination from the environment to food

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or food-handling surfaces [20]. Environments with open waste, flies, and rodents pose a dual risk: they reflect poor sanitation control and serve as mechanical vectors that transfer pathogens to ingredients, utensils, or surfaces [21]. For example, a study among street food vendors in Nairobi, Kenya found that the presence of rodents increased contamination risks by 5.9 times compared with rodent-free areas [22]. This demonstrates that physical environment conditions are not merely background factors, but a primary contamination pathway. Meanwhile, the variable of risk-control efforts showed relatively better results (46.7% meeting standards), although still suboptimal. Most restaurant managers lacked routine supervision systems or periodic sanitation inspections, indicating the need to strengthen risk-based food sanitation inspection systems [23].

Laboratory examinations revealed that 33 out of 60 restaurants (55%) tested positive for *Salmonella* sp. This is highly concerning, as more than half of the foods sold in the study area failed to meet food safety standards outlined in MOH Regulation No. 2/2023 regarding the quality requirements of ready-to-eat foods. This indicates that the food processing chain in the study area continues to exhibit major weaknesses in microbiological safety, particularly related to *Salmonella*, a key agent in foodborne illnesses [24]. The high prevalence of *Salmonella* contamination is likely linked to poor environmental conditions, inadequate personal hygiene practices, and a lack of basic sanitation facilities such as proper handwashing stations, clean water, and effective waste management [25]. However, the detection of *Salmonella sp.* does not differentiate between typhoidal and non-typhoidal strains. Thus, the findings should be interpreted as evidence of food safety issues and potential foodborne disease risk, rather than a direct measure of typhoid fever transmission.

Biochemically and epidemiologically, *Salmonella* sp. is a Gram-negative genus capable of contaminating food, surviving poor processing conditions, and causing diseases such as typhoid fever (for certain serovars), acute gastroenteritis, and other foodborne infections. In the context of ready-to-eat food processing, contamination typically occurs through direct contact with raw contaminated ingredients, unclean food handlers' hands, contaminated surfaces, or contaminated washing water. Previous studies further support that the prevalence of *Salmonella* sp. in ready-to-eat foods in Indonesia and elsewhere remains high. A study in Patrang District found that 80% of raw vegetable salad samples were contaminated with *Salmonella* spp. [26]. Additionally, research on ready-to-eat sushi in the Greater Jakarta area found a *Salmonella* prevalence of 2.5%, indicating that minimally heated ready-to-eat foods still carry significant risks [27]. Similarly, another study found that 50% of ready-to-eat gado-gado samples were contaminated with *Salmonella* sp., while 60% of vendors had poor personal hygiene [28]. *Salmonella* sp. is a major causative agent of typhoid fever, gastroenteritis, and foodborne infections, transmitted mainly through food and water contaminated by human or animal feces.

Bivariate analysis shows significant associations between physical environmental conditions, hygiene and sanitation practices in food processing, food handlers' personal hygiene, and environmental contamination risks with the presence of *Salmonella* sp. in foods sold in restaurants and food stalls within the Kassi-Kassi Health Center working area. After correcting the reference categories, all significant variables showed OR > 1, indicating that restaurants that did not meet the criteria had a higher risk of contamination. This aligns with epidemiological principles where poor conditions act as risk factors rather than protective factors. Poor ventilation, inadequate lighting, and the presence of vectors such as flies and rodents serve as major contributors to pathogenic bacterial contamination [29]. Damp and unmaintained environments support the growth of microorganisms such as *Salmonella*, *E. coli*, and *Shigella*, especially in food preparation areas lacking proper sanitation systems [30]. Many restaurants in this study lacked standard environmental sanitation facilities such as closed waste disposal systems and hygienic trash bins. This creates opportunities for cross-contamination, either directly or indirectly [31]. Furthermore, hygiene and sanitation of food processing showed a significant association with *Salmonella* presence ($p = 0.009$; OR = 0.214; 95% CI = 0.064–0.716). Poor food-processing hygiene significantly increases the risk of bacterial contamination. Practices such as using dirty equipment, washing raw ingredients with contaminated water, and storing raw and cooked foods together contribute to microbiological hazards. This aligns with research showing that neglecting basic sanitation is one of the main pathways for *Salmonella* contamination in ready-to-eat foods [32]. Implementing food safety systems such as Good Food Handling Practices and Hazard Analysis Critical Control Point (HACCP) is essential to ensure each food-processing stage remains within safe contamination limits [33].

A strong association was also observed for food handlers' personal hygiene, with $p = 0.042$ and OR = 3.600 (95% CI = 1.003–12.919). This indicates that food handlers with poor personal hygiene have a 3.6-times higher risk of contributing to *Salmonella* contamination than those with good hygiene. This emphasizes the crucial role of hand hygiene, PPE use, and overall cleanliness. Research by Susanna et al. (2020) found that handwashing behavior and PPE use strongly influence foodborne disease prevention. In this study, most food handlers did not use gloves, masks, and had long or dirty nails, all of which act as transmission media for *Salmonella*. Environmental contamination risk was also significantly associated with *Salmonella* presence ($p = 0.023$; OR = 0.289; 95% CI = 0.097–0.861). Factors such as stagnant water, open drainage, and poor waste management facilitate the growth of bacteria and their transfer to food ingredients or utensils through insects, dust, or water splashes. These findings align with studies showing that poor environmental cleanliness is strongly associated with *Salmonella* contamination in street foods in urban areas [34]. Meanwhile, risk-control efforts did not show a

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significant association with *Salmonella* contamination (p = 0.405; OR = 0.647; 95% CI = 0.232–1.808). This finding suggests that the implementation of control measures may not have been effective or consistently applied. Field observations indicated that many control efforts, such as the provision of handwashing facilities, sanitation guidelines, or hygiene training, were implemented only as formal requirements without regular monitoring or enforcement. In some cases, facilities were available but not utilized properly by food handlers. This indicates a gap between policy and practice, where compliance is administrative rather than behavioral. A deeper qualitative assessment suggests that lack of supervision, weak institutional enforcement, and low risk perception among food handlers may explain why these measures did not significantly reduce contamination risk[35].

Overall, this study highlights the importance of environmental sanitation and food handlers' behavior in influencing food contamination. However, all interpretations must be limited to microbiological contamination risk, not direct typhoid fever incidence. Claims regarding typhoid transmission should be made cautiously and require further confirmation through pathogen-specific identification such as *Salmonella typhi* serotyping. Strengthening hygiene practices, improving environmental sanitation, and ensuring consistent implementation of food safety systems such as HACCP are essential to reduce contamination risks. In addition, previous references to WHO (2021) regarding foodborne disease burden should be interpreted carefully and replaced with verifiable sources where necessary to maintain scientific accuracy.

This study has several limitations. First, the cross-sectional design limits causal inference. Second, the study was limited to a specific geographic area. Third, a major limitation is that laboratory analysis only detected *Salmonella sp.* at the genus level without distinguishing serotypes, which restricts the ability to directly associate findings with typhoid fever caused by *Salmonella typhi*. Fourth, observational bias may have occurred during hygiene assessment. Fifth, the short data collection period may not reflect temporal variations. These limitations suggest the need for future studies using longitudinal designs and advanced microbiological methods, including serotyping or molecular identification, to provide more specific and comprehensive results.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that environmental exposure related to restaurant food is a potential risk factor for Salmonella transmission associated with typhoid fever, rather than a direct driver of typhoid fever incidence in Makassar City. Several key determinants showed significant associations with microbial contamination, including physical environmental conditions (p = 0.002; OR = 6.25), hygiene and sanitation practices during food processing (p = 0.009; OR = 4.67), food handlers' personal hygiene (p = 0.042; OR = 3.60), and environmental contamination risk (p = 0.023; OR = 3.46). All significant variables indicate that restaurants not meeting health criteria have a higher likelihood of Salmonella contamination (OR > 1), confirming their role as risk factors. These findings reflect increased risk of Salmonella contamination in food, not a direct increase in typhoid fever incidence, as laboratory analysis was limited to genus-level identification (Salmonella sp.) without serotype confirmation. Therefore, interpretations related to typhoid transmission should be made cautiously. The results highlight the importance of comprehensive interventions, including hygiene education for food handlers, implementation of the Hazard Analysis and Critical Control Point (HACCP) system, and strengthening risk-based sanitation inspections by public health authorities. These efforts are essential to reduce contamination pathways and improve food safety in restaurant settings. Strengthening supervision, regulatory enforcement, and collaboration between restaurant owners and health agencies is also necessary to ensure sustainable improvements in environmental hygiene.

CONFLICT OF INTEREST

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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