
FACTORS ASSOCIATED WITH MICROBIAL CONTAMINATION IN CATERING FOOD SERVICES IN PALEMBANG CITY, SOUTH SUMATRA

Faiza Yuniati,^{*1} Karina Anggraini², Efriza³, Rismarini⁴

¹Departement of Epidemiologic Surveillance, Palembang Health Polytechnic, South Sumatera, Indonesia,

²Student of Enviromental Sanitation Departement, Palembang Health Polytechnic, South Sumatera, Indonesia,

³Public Health Department, Fort De Kock University, Bukit Tinggi, Indonesia

⁴Public health laboratory center Palembang, South Sumatera, Indonesia

Correspondence Author: Faiza Yuniati, faizayuniati@poltekkespalembang.ac.id

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ABSTRACT

Background: Food safety is critical to public health, particularly in catering services where food is prepared and distributed in bulk, increasing the risk of microbial contamination. Understanding the contributing factors to microbial contamination in such settings is essential for developing effective prevention strategies. **Purpose:** This study aimed to determine factors associated with microbial contamination in catering food services within the Padang Selasa Health Center area of Palembang City. **Methods:** A quantitative cross-sectional design was employed, involving 50 food handlers and 20 food samples (rice and animal-based side dishes). Microbial counts were analyzed following the Indonesian National Standard (SNI 7388:2009). Independent variables included demographic characteristics (age, gender, education, work experience), knowledge, hygiene-sanitation behaviour, and environmental factors (temperature and humidity). **Results:** Results revealed a mean microbial count of 11,632 colonies/25 grams, with significant negative correlations between microbial contamination and food handlers' age, tenure, knowledge, and hygiene behaviour ($p < 0.05$). Positive correlations were observed between microbial counts and storage temperature as well as food ingredient selection, while relative humidity showed a negative association. No significant relationships were found with gender or education level. **Conclusion:** These findings underscore the critical role of food handler experience, knowledge, sanitation behaviour, and environmental controls in mitigating microbial contamination in catering food. The study recommends targeted, continuous training and stringent environmental management to enhance food safety and public health in community catering services.

Correspondence Author: Faiza Yuniati,
faizayuniati@poltekkespalembang.ac.id
Departement of Epidemiologic
Surveillance, Palembang Health
Polytechnic, South Sumatera, Indonesia

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INTRODUCTION

Ensuring food safety in catering services remains a pivotal concern in public health, particularly given the significant risk posed by microbial contamination in food preparation environments. Numerous studies have established a strong link between foodborne disease outbreaks and lapses in food-handling practices by food service personnel (Erdoğan & Pamuk, 2019; Akabanda et al., 2017; Kumar et al., 2022; Silva & Martínez, 2020; Thompson et al., 2024; Wu & Chang, 2023; Zhang et al., 2022). Food handlers serve as the critical point of contact between prepared food and consumers, and their behaviours, knowledge, and hygiene practices directly influence microbial counts in food. Despite global efforts to improve food safety standards, challenges persist, particularly in low- and middle-income countries where resources and systematic training may be limited (Gemed, 2018; Htway & Kallawicha, 2020; Fernandez & Torres, 2022; Green & Patel, 2023; Lopez et al., 2020; Nguyen & Tran, 2024; Park et al., 2023).

Recent studies also emphasize the importance of integrating mobile technology and digital education platforms in enhancing food safety behaviour among food handlers, especially in informal or small-scale food services (Rahim et al., 2023; Delgado et al., 2024). The role of education and structured training programs has gained recognition for its potential to significantly reduce microbial contamination in food service operations. Empirical evidence demonstrates that food handlers who have undergone training and possess at least secondary education are more likely to adhere to proper food safety protocols, leading to reduced microbial loads in food (Asim et al., 2019; Malavi et al., 2021; Lami et al., 2019; Fernandez & Torres, 2022; Islam & Rahman, 2020; Jackson & Smith, 2023). Furthermore, factors such as gender and employment tenure have also been observed to influence hygienic behaviour and food safety knowledge, with some studies indicating that female food handlers often outperform their male counterparts in maintaining cleanliness standards (Mahat et al., 2016; Madeghe et al., 2021).

The continued prevalence of foodborne illnesses associated with microbial contamination underscores the urgent need to evaluate contributory factors in specific local contexts. In the case of Palembang City, Indonesia, the proportion of food service establishments meeting health standards remains suboptimal, with considerable variation across districts. The Padang Selasa Health Center area, despite having no recorded incidents of food poisoning from catering, lacks comprehensive data on the relationship between food handlers' practices and microbial food contamination, necessitating targeted investigation (Ayad et al., 2022; Gemed, 2018; Ahmed et al., 2023; Liu & Chen, 2021; Rahman et al., 2024; Tanaka & Suzuki, 2022).

The general solution lies in identifying and analyzing the relationships between demographic, behavioural, and environmental variables associated with food handlers and the microbial quality of the food they prepare. By utilizing structured quantitative methodologies and validated instruments, public health professionals can derive evidence-based insights to inform policy and training interventions aimed at reducing food contamination levels. Previous research highlights the value of integrating routine assessments, continuous training, and behavioural reinforcement to foster safe food-handling environments (Lee et al., 2017; Nawawi et al., 2022; Erdoğan & Pamuk, 2019; Asim et al., 2019).

Several studies offer concrete strategies to mitigate microbial contamination in catering services through targeted educational interventions. For instance, Malavi et al. (2021) reported that structured food safety training significantly improved the hygiene behaviours of food handlers, ultimately reducing microbial contamination. Similarly, Asim et al. (2019) demonstrated that safe food handling knowledge among service managers was positively associated with the implementation of sanitary practices, reinforcing the importance of informed supervision in food service settings.

The influence of education and professional experience has also been well-documented. Lami et al. (2019) and Madeghe et al. (2021) found that food handlers with higher educational attainment and participation in safety training exhibited better hygiene and lower contamination risks. However, these outcomes are not uniformly distributed; Kayshar et al. (2021) noted that increased age and experience do not always correlate with improved practices, indicating the need for ongoing training regardless of tenure. Furthermore, effective hygiene behaviour, particularly handwashing, plays a critical role in minimizing contamination. Erdoğan and Pamuk (2019) highlighted the prevalence of microbial contamination due to improper hand hygiene, an observation echoed by Ayad et al. (2022), who emphasized the need for sustained hygiene education and monitoring. These findings collectively advocate for context-specific interventions that address not only knowledge deficits but also behavioural and environmental factors affecting food safety in catering operations. While extensive literature underscores the efficacy of training and education in improving

food safety practices, there remains a significant gap in understanding how these findings translate into localized contexts, such as in Indonesia's decentralized public health landscape. Most previous studies have focused on general populations or institutional food services, with limited evidence about small-scale catering businesses in community health service areas like Padang Selasa. Additionally, there is a paucity of data integrating both behavioural assessments and microbial measurements in the same study context (Banna et al., 2021; Jores et al., 2018).

Moreover, inconsistencies in the relationship between demographic factors and food safety practices suggest that universal assumptions may not be applicable across all populations. Despite training interventions, studies by Lee et al. (2017) and Gemeda (2018) reveal a disconnect between knowledge and practice, indicating that information alone may be insufficient to drive behaviour change. Thus, there is a critical need to investigate these associations using empirical data from diverse and underserved settings to generate context-specific insights and improve public health outcomes.

The objective of this study is to determine the factors associated with the number of germs in food services operating in the Padang Selasa Health Center area of Palembang City. The study hypothesizes a relationship between demographic characteristics, knowledge, food ingredient selection, and sanitary hygiene behaviour of food handlers with microbial counts in catering food. This research offers a novel contribution by integrating demographic, behavioural, and microbiological data in a single cross-sectional framework within a localized Indonesian context, addressing critical gaps in the literature concerning small-scale catering enterprises.

METHODS

This study employed a quantitative, cross-sectional design conducted in the operational area of the Padang Selasa Health Center, Palembang City. The study involved 50 food handlers working in local catering food services and analyzed 20 food samples (comprising rice and animal-based side dishes) to determine associations between various factors and microbial contamination levels in prepared food. The research aimed to generate empirical evidence with practical implications for food safety management in similar community health service contexts.

Materials and Tools: The materials used in this study consisted of both human and food components. Human samples included 50 food handlers from various catering services within the study area. Food samples consisted of 20 items, specifically rice and animal-based side dishes. Each sample weighed 100 grams, was wrapped in sterile aluminium foil, stored in a portable cooler box with ice packs at temperatures below 4°C, and transported to the Environmental Health Center and Disease Control Laboratory Palembang within four hours of collection for microbial analysis. The tools and instruments used in this study included a calibrated digital thermo-hygrometer, to measure storage temperature (°C) and relative humidity (%) in food storage areas. Sterile sampling equipment such as sterile gloves, foil wrappers, tongs, and food-grade containers for hygienic sample collection. Laboratory tools, including media for aerobic plate counts and standard microbiological equipment. Microbial analysis adhered to the Indonesian National Standard (SNI 7388:2009), and results were documented under certificate number UM.01.05/1/1515/2023. Structured questionnaires, were used to assess food handlers' demographic characteristics, food safety knowledge, and hygiene-sanitation behaviours. The knowledge questionnaire included 25 items addressing topics such as foodborne illnesses, use of personal protective equipment, and food handling practices. The hygiene-sanitation behaviour questionnaire also contained 25 items evaluating cleanliness practices, sanitation habits, and contamination risk. These materials and tools were adapted from validated instruments and previous food safety studies (Lee et al., 2017; Mahat et al., 2016; Nawawi et al., 2022).

Data Collection and Measurement. Primary data on food handlers' characteristics, knowledge, and hygiene practices were collected via structured questionnaires. Environmental data: temperature and humidity were recorded directly at the food storage sites using the digital thermo-hygrometer. The dependent variable was microbial count, measured in colony-forming units (CFU) per 25 grams of food, based on laboratory results. Independent variables included age, gender, education level, work experience (tenure), food safety knowledge, hygiene-sanitation behaviour, and environmental conditions. Gender was categorized as male or female (nominal). Education level was categorized as primary, secondary, or tertiary (ordinal). Other variables (age, tenure, knowledge, hygiene behaviour, temperature, humidity) were measured on an interval scale.

Data Analysis. Descriptive statistics were used to summarize demographic data and environmental measurements. Inferential statistics were applied to assess associations between independent variables and

microbial contamination: Spearman's rank correlation was used for interval and ordinal variables due to non-normal data distribution (confirmed via Shapiro-Wilk test, $p < 0.05$). Mann-Whitney U tests evaluated differences in microbial contamination based on gender. Kruskal-Wallis tests assessed differences across education levels. This statistical approach aligns with the analytical techniques applied in similar public health studies involving microbial risk assessment (Gemed, 2018; Ayad et al., 2022).

RESULTS

Based on Table 1, it can be observed that the average microbial count in food samples collected from each catering service was 11,632.00 colony-forming units (CFU) per 25 grams. The lowest recorded microbial count was 490 CFU/25g, while the highest was 34,000 CFU/25g. The distribution of microbial count data from catering food samples was tested using the Shapiro-Wilk normality test. The result yielded a p-value of 0.000, indicating that the microbial count data were not normally distributed.

Table 1
Distribution of Microbial Counts in Catering Food in the Padang Selasa
Health Center Work Area

Dependent Variable	Mean	Min	Max
Microbial Count (CFU/25g)	11632.00	490	34000

Table 2 shows that the 50 food handlers had an average age of 45 years, with the youngest being 25 years old and the oldest 66 years. The mean duration of work experience was 3 years, ranging from 1 to 5 years. Knowledge scores, measured through a questionnaire, averaged 15 points, with a minimum of 10 and a maximum of 21. Hygiene and sanitation behaviour scores had a mean of 68 points, ranging from 50 to 86. Environmental measurements of the cooked food storage areas indicated an average temperature of 32°C (30–35°C) and an average relative humidity of 62% (60–65%).

Table 2
Descriptive Statistics of Numerical Independent Variables

Variable (n=50)	Min	Max	Mean
Age (years)	25	66	45
Works Experience (years)	1	5	3
Knowledge (points) score	10	21	15
Hygiene Sanitation Behavior Score	52	86	68
Storage Temperature (°C)	30	35	32
Relative Humidity (%)	60	65	62

As shown in Table 3, the majority of the food handlers were female (72.0%), and most had secondary education (64.0%).

Table 3
Descriptive Statistics of Categorical Independent Variables

Variable (n=50)	Frequency	Percentage (%)
Gender		
Male	14	28
Female	36	72
Educational Level		
Primary School	18	36
Secondary School	32	64

The bivariate correlation analysis revealed several significant associations between the independent variables and microbial contamination levels in catering food. A moderate negative correlation was found between microbial counts and the food handlers' age ($r = -0.409$; $p = 0.003$), work experience ($r = -0.426$; $p = 0.002$), knowledge ($r = -0.323$; $p = 0.022$), and hygiene-sanitation behaviour ($r = -0.297$; $p = 0.036$). These results indicate that older, more experienced, and more knowledgeable food handlers who demonstrate better hygiene practices tend to produce food with lower microbial contamination. Conversely, storage temperature ($p = 0.007$) showed significant moderate positive correlations with microbial counts, suggesting that suboptimal ingredient choices and higher storage temperatures contribute to increased contamination. Relative humidity was found to be negatively correlated with microbial counts ($r = -0.309$; $p = 0.029$), indicating that higher humidity may reduce contamination under certain conditions. All observed correlations were statistically significant ($p < 0.05$), confirming the relevance of these factors in determining food safety outcomes (Table 4).

Table 4
Bivariate Correlation Between Independent Variables
and Microbial Counts in Catering Food (n = 50)

Independent Variable	Spearman's Rho (r)	P-value	Strength & Direction of Correlation
Age	-0.409	0.003	Moderate, Negative
Work Experience	-0.426	0.002	Moderate, Negative
Knowledge	-0.323	0.022	Moderate, Negative
Hygiene Sanitation	-0.297	0.036	Moderate, Negative
Storage Temperature	0.378	0.007	Moderate, Positive
Relative Humidity	-0.309	0.029	Moderate, Negative

Based on the Mann-Whitney U test, no significant relationships were found between microbial counts and categorical variables such as gender and education level. For gender, the Z-value was -0.543 with a p-value of 0.587, indicating no significant difference in microbial contamination between male and female food handlers. Similarly, for education level, the Z-value was -0.102 with a p-value of 0.919, suggesting that microbial contamination levels did not significantly differ between food handlers with primary and secondary education (Table 5).

Table 5
Bivariate Analysis of Categorical Variables and
Microbial Counts in Catering Food (n = 50)

Variable	Z-value	P-value*
Gender	-0,543	0,587
Education	-0,102	0,919

*Mann-Whitney U Test

DISCUSSION

The findings of a significant negative correlation between food handlers' age, tenure, knowledge, and hygiene behaviour with microbial contamination align with previous research emphasizing the critical role of experience and food safety awareness in reducing microbial risk (Malavi et al., 2021; Asim et al., 2019; Lami et al., 2019). Similar to Erdoğan and Pamuk (2019), who underscored the importance of proper hygiene practices in minimizing microbial contamination, this study confirms that higher knowledge and better sanitation behaviour correspond with lower germ counts. The positive association between storage temperature and microbial contamination observed here supports established literature identifying temperature control as a key environmental determinant influencing microbial growth in food (Ayad et al., 2022; Htway &

Kallawicha, 2020). The negative correlation between relative humidity and microbial counts, while less commonly reported, suggests environmental complexity in microbial proliferation dynamics, which warrants further investigation. This relationship is further supported by recent evidence showing that temperature fluctuations as minor as $\pm 2^{\circ}\text{C}$ can significantly affect microbial proliferation, particularly in protein-rich foods such as meats and stews commonly served in catering (Novitasari et al., 2023; Chang et al., 2024).

Contrasting with some studies indicating that education significantly influences food safety knowledge and practices (Lami et al., 2019; Madeghe et al., 2021), this study did not find a statistically significant association between education level and microbial contamination. This may reflect contextual differences or the limited educational variability within the sample. Additionally, the absence of gender influence aligns with findings by Nawawi et al. (2022), suggesting that gender effects may be culturally or regionally dependent. These results substantiate the hypothesis that food handler characteristics, specifically age, tenure, knowledge, and hygiene-sanitation behaviours are integral to mitigating microbial contamination in catering food. Scientifically, the study reinforces the multifactorial nature of food safety, highlighting the intertwined influence of human factors and environmental conditions on microbial loads.

Practically, the findings emphasize the necessity for targeted, continuous training programs focusing on enhancing food handlers' knowledge and hygiene behaviour, especially in younger or less experienced personnel. Control of storage temperature emerges as an actionable environmental parameter to mitigate microbial risks. Public health authorities and catering service managers should prioritize interventions that address these factors to reduce foodborne illness risks. Moreover, the lack of significant association between education level and microbial contamination suggests that training and behavioural interventions may be more critical than formal education in improving food safety outcomes. Future programs should therefore tailor content and delivery methods to local contexts and emphasize practical hygiene applications. These implications align with global calls for comprehensive food safety management incorporating human behaviour, knowledge reinforcement, and environmental monitoring (Akabanda et al., 2017; Gameda, 2018).

The present study's findings elucidate critical determinants of microbial contamination in catering food within the Padang Selasa Health Center area, underscoring the multifaceted interplay between food handler demographics, knowledge, hygiene behaviour, and environmental conditions. The significant negative correlations between microbial counts and food handlers' age, tenure, knowledge, and sanitation behaviour provide empirical support for behavioural and educational theories positing that experience and cognitive awareness substantially influence adherence to safe food handling practices (Chen & Lee, 2022; Patel et al., 2023; Ramirez et al., 2020; Gomez & Tran, 2019; Wong et al., 2024; Li & Wang, 2021). These correlations echo the Theory of Planned Behavior, wherein knowledge and attitudes inform intention and subsequent behaviour, ultimately affecting food safety outcomes.

Consistent with Malavi et al. (2021) and Asim et al. (2019), this study demonstrates that food handlers with greater knowledge and longer work experience exhibit lower microbial contamination in food, likely due to enhanced competence and habitual application of hygienic practices. This finding aligns with social learning theory, which suggests that practical experience and observed outcomes reinforce food safety behaviours over time (Patel et al., 2023; Wong et al., 2024). Moreover, the observed linkage between hygiene-sanitation behaviour and microbial counts corroborates prior research emphasizing hand hygiene as a cornerstone of contamination prevention (Erdoğan & Pamuk, 2019; Ayad et al., 2022; Ramirez et al., 2020). The moderate effect size indicates that while knowledge is necessary, effective translation into behaviour remains a challenge, reflecting similar gaps highlighted in Gameda (2018), where knowledge alone did not guarantee safe practices.

The study's findings on environmental parameters further affirm established microbiological principles that microbial proliferation is temperature-dependent, with higher storage temperatures favouring bacterial growth (Htway & Kallawicha, 2020; Li & Wang, 2021). The positive correlation between storage temperature and germ counts underscores the critical role of environmental controls in food safety management systems. Interestingly, the negative correlation with relative humidity suggests that factors beyond simple moisture availability influence microbial dynamics, potentially reflecting complex interactions involving air circulation, condensation, and microbial species-specific responses. This nuance highlights the need for further research integrating environmental microbiology with food safety practices.

Contrary to many studies positing education as a key predictor of food safety knowledge and behaviour (Lami et al., 2019; Madeghe et al., 2021), this research did not find a significant association between education level and microbial contamination. This discrepancy may reflect contextual specificity, where formal education does not necessarily translate into food safety competency without targeted training,

as proposed in competency-based education frameworks (Ramirez et al., 2020). It also suggests that interventions focused solely on educational attainment may be insufficient without concurrent behavioural and environmental strategies. The absence of a significant gender effect aligns with findings by Nawawi et al. (2022) and highlights that gender differences in food safety practices may be culturally mediated or mitigated by workplace norms.

The findings of a significant negative correlation between food handlers' age, tenure, knowledge, and hygiene behaviour with microbial contamination align with previous research emphasizing the critical role of experience and food safety awareness in reducing microbial risk (Malavi et al., 2021; Asim et al., 2019; Lami et al., 2019). Similar to Erdoğan and Pamuk (2019), who underscored the importance of proper hygiene practices in minimizing microbial contamination, this study confirms that higher knowledge and better sanitation behaviour correspond with lower germ counts. The positive association between storage temperature and microbial contamination observed here supports established literature identifying temperature control as a key environmental determinant influencing microbial growth in food (Ayad et al., 2022; Htway & Kallawicha, 2020). The negative correlation between relative humidity and microbial counts, while less commonly reported, suggests environmental complexity in microbial proliferation dynamics, which warrants further investigation. Contrasting with some studies indicating that education significantly influences food safety knowledge and practices (Lami et al., 2019; Madeghe et al., 2021), this study did not find a statistically significant association between education level and microbial contamination. This may reflect contextual differences or the limited educational variability within the sample. Additionally, the absence of gender influence aligns with findings by Nawawi et al. (2022), suggesting that gender effects may be culturally or regionally dependent.

Further, recent studies emphasize the importance of continuous food safety training programs tailored to the specific needs of food handlers to effectively improve hygiene practices and reduce microbial contamination (Smith et al., 2021; Chen & Lee, 2022; Patel et al., 2023). This supports the notion that beyond formal education, ongoing practical training significantly enhances food safety outcomes by fostering behavioural change and reinforcing safe food handling techniques (Ramirez et al., 2020; Wong et al., 2024). Moreover, the integration of technology-driven interventions, such as mobile learning and digital reminders, has been shown to effectively promote adherence to hygiene protocols among food handlers, especially in resource-limited settings (Li & Wang, 2021; Gomez & Tran, 2019). These findings reinforce the necessity for innovative, context-specific approaches to augment food safety knowledge and practices.

Environmental factors, particularly temperature control, continue to play a pivotal role in microbial contamination risk, as corroborated by several recent investigations highlighting the effects of fluctuating storage temperatures and inconsistent refrigeration on food quality (Ahmed et al., 2023; Liu & Chen, 2021). The complex interplay between relative humidity and microbial growth also requires further elucidation, as emerging evidence points to varied microbial responses based on species and environmental conditions (Rahman et al., 2024). Collectively, these studies underscore the need for comprehensive food safety strategies that incorporate both human behavioural factors and meticulous environmental management to mitigate contamination risks in catering and other food service operations.

Research Limitations: This study has several limitations that should be acknowledged. First, the cross-sectional design limits the ability to establish causal relationships between food handler characteristics, behaviours, environmental factors, and microbial contamination. Longitudinal studies would provide stronger evidence on temporal dynamics and causality. Second, the relatively small sample size of 50 food handlers and 20 food samples may restrict the generalizability of the findings to broader populations or other geographic areas with differing socio-cultural or environmental conditions. Third, data on knowledge and hygiene behaviour were self-reported via questionnaires, which may introduce social desirability and recall biases, potentially inflating reported compliance with food safety practices. Fourth, the study focused primarily on total microbial counts without detailed identification of specific pathogenic microorganisms, limiting insights into particular health risks. Lastly, environmental measurements were limited to temperature and humidity at the time of sampling; dynamic variations over time or other factors such as ventilation and contamination sources were not assessed. Future research should address these limitations by employing larger, more diverse samples, objective behavioural observations, pathogen-specific microbiological analyses, and comprehensive environmental monitoring.

CONCLUSION

This study concludes that microbial contamination in catering food within the Padang Selasa Health Center area is significantly influenced by food handlers' age, tenure, knowledge, and hygiene-sanitation behaviour, as well as environmental factors such as storage temperature and humidity. Older and more experienced food handlers with higher knowledge levels and better sanitation practices tend to produce food with lower microbial counts. Environmental conditions, particularly higher temperatures, are associated with increased microbial contamination, underscoring the importance of proper food storage management. No significant associations were found between microbial contamination and food handlers' gender or education level. These findings highlight the critical need for targeted, continuous training programs focused on improving food safety knowledge and hygiene behaviour alongside strict environmental control measures. Implementing multifaceted interventions tailored to local contexts can effectively reduce microbial contamination risks in catering services, thereby enhancing public health outcomes.

CONFLICT OF INTEREST

The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

AUTHOR CONTRIBUTIONS

All authors actively participated in the research and manuscript preparation and are jointly responsible for the content of the article, including the development and writing of the concept, design, analysis, and revisions. FY contributed to the conceptualization, methodology, data analysis, and original draft preparation. KA was responsible for field data collection and investigation. FY, EF, and RI contributed to the writing, review, and editing of the manuscript.

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