Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: https://www.science-gate.com/IJAAS.html

Evaluation of microbial contamination and food safety knowledge among institutional food handlers

Jo Neil T. Peria *

College of Education, Nueva Ecija University of Science and Technology, Cabanatuan City, Nueva Ecija 3100, Philippines

ARTICLE INFO

Article history:
Received 21 September 2025
Received in revised form
6 February 2026
Accepted 17 February 2026

Keywords:
Applied microbiology
Food safety
Pathogen awareness
Microbial contamination
Higher education canteens

ABSTRACT

This study used a combined microbiological and behavioral approach to evaluate food safety in a higher education institution canteen in Nueva Ecija, Philippines. Microbiological tests were conducted on food samples and contact surfaces to detect *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus cereus* following ISO standards. In addition, 65 food handlers completed a validated survey to assess their food safety knowledge, attitudes, and practices (KAP), as well as their awareness of foodborne pathogens. The results showed that microbial counts in all tested samples were within acceptable limits, although occasional detections indicated possible weaknesses in cold chain management and sanitation practices. Significant positive correlations were found between food safety KAP and pathogen awareness ($r = 0.416–0.446$, $p < 0.001$). Both KAP and pathogen awareness were significantly negatively associated with microbial presence ($r = –0.246$ to $–0.342$, $p < 0.05$). These findings indicate that higher levels of food safety knowledge and pathogen awareness are associated with lower microbial contamination. The study highlights the practical importance of combining microbiological monitoring with targeted training programs to strengthen institutional food safety systems and reduce contamination risks.

1. Introduction

Foodborne illnesses remain a persistent public health concern worldwide, with significant implications for food safety and microbiological quality, particularly in institutional food service settings such as university canteens, where food is prepared and consumed on a large scale (Ramos and Despojo, 2025). The global emergence of foodborne pathogens continues to pose serious health and economic risks, underscoring the importance of microbiological safety as a central issue in applied food sciences (Odeyemi and Bamidele, 2016). Despite increasing recognition of food safety protocols and the publication of key works, foodborne disease outbreaks remain prevalent, especially in low- and middle-income countries where evidence and systematic studies remain limited (Grace, 2015).

In the Philippines, food handling practices have received growing attention due to the predominance of small- to medium-scale establishments and the heightened risk of contamination in large institutions such as schools. In these environments, food consumption involves multiple handlers and multi-level preparation processes, raising the potential for microbial contamination if safety standards are inconsistently applied (Reyes, 2020). Microbiological monitoring in such institutional settings is therefore critical to identifying contamination risks and ensuring safe consumption. In higher education institutions, these food safety efforts operate within broader quality assurance and governance systems that influence policies, resource allocation, and compliance with standards such as ISO-based protocols (De Lara and Santos, 2024; Gamit et al., 2024; Jacoba et al., 2024).

Beyond microbiological surveillance, food handler practices play an essential role in food safety outcomes. However, much of the existing literature tends to examine knowledge, attitudes, and practices (KAP) in isolation, without directly linking these behavioral factors to empirical microbiological data from food environments. This leaves a critical research gap in determining whether improved food safety literacy and pathogen awareness among handlers translate into measurable reductions in

* Corresponding Author.
Email Address: joneiltolentinoperia@gmail.com
https://doi.org/10.21833/ijaas.2026.02.019
Corresponding author's ORCID profile:
https://orcid.org/0009-0007-0536-4574

contamination. This study aims to address that gap by integrating two complementary approaches: (1) microbiological analysis of food and contact surfaces for common pathogens, and (2) evaluation of food handlers' knowledge, attitudes, practices, and pathogen awareness. By correlating microbiological findings with KAP and awareness data, the study seeks to generate applied insights into how both technical monitoring and human factors interact in institutional food safety systems. Strengthening such systems in higher education environments is not only essential for protecting public health but also for fostering a culture of accountability and awareness among food service workers.

2. Materials and methods

The study was conducted in a selected campus of a higher education institution in Nueva Ecija, Philippines. The respondents were university canteen food handlers, including workers responsible for preparing, cooking, and selling food and drinks. A total enumeration sampling technique was employed to capture all eligible participants, resulting in 65 food handlers included in the study. This approach ensured reliable representation of the food service workforce in the institution, as the respondents comprised all food handlers employed in the university canteen at the time of data collection.

A structured survey instrument was designed by the researcher to measure four dimensions: (1) food safety knowledge, (2) food safety attitudes, (3) food safety practices, and (4) food pathogen awareness. The questionnaire consisted of 40 items, divided into four thematic sections. Each item was rated on a five-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). To establish content validity, the questionnaire underwent expert review and validation, followed by a pilot test with 80 participants. Feedback from the pilot was used to refine item clarity and reliability, ensuring that the instrument consistently captured the intended constructs and improved the robustness of findings. In the pilot test with 80 participants, internal consistency was assessed using Cronbach's alpha. The 40-item instrument demonstrated acceptable reliability for the overall scale as well as for each of the four subscales, namely food safety knowledge, food safety attitudes, food safety practices, and food pathogen awareness.

In parallel with the survey, microbiological assessments were conducted on selected food items and contact surfaces in the university canteen. Samples were tested for the presence of *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus cereus*, following ISO-based protocols and microbiological standards. The testing process evaluated microbial contamination levels in drinks, meals, frozen foods, tables, and utensils to determine compliance with internationally recognized food safety benchmarks. *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus cereus* were enumerated following internationally recognized ISO standards for food microbiology. Coagulase-positive S. aureus counts were determined using methods from the ISO 6888 series, β-glucuronidase–positive *E. coli* using methods from the ISO 16649 series, and presumptive B. cereus using ISO 7932. Standard procedures for sample preparation, serial dilution, plating on selective agar media, incubation at specified temperatures and times, and subsequent colony enumeration were followed, with results expressed as colony-forming units per gram (CFU/g), per milliliter (CFU/ml), or per square centimeter (CFU/cm^2), as appropriate for each sample type. The application of ISO-based microbiological methods in this study is consistent with wider institutional efforts to align with formal quality management and accreditation frameworks in state universities and colleges (Gamit et al., 2024).

To examine relationships among the study variables, statistical analyses were carried out using Pearson's r and Spearman's rho correlation tests. These analyses explored the associations between (1) food safety knowledge, attitudes, and practices; (2) pathogen awareness; and (3) microbiological contamination levels observed in the canteen environment.

3. Results and discussion

3.1. Food safety

The findings of the study revealed that respondents demonstrated high levels of food safety knowledge, particularly in key areas such as personal hygiene, prevention of cross-contamination, and time and temperature control. This result indicates that both food handlers and consumers in the university setting are well-informed about essential practices that help prevent foodborne illnesses. These findings are comparable to results in Ghana, where most school canteen food handlers displayed strong knowledge regarding proper handwashing (93.6%), the importance of food temperature (82.6%), and the dangers of cross-contamination—critical elements in minimizing foodborne illness risks (Tuglo et al., 2021). Similar patterns have been observed among Lebanese hospital food handlers, who showed sound general hygiene knowledge, though gaps remained in pathogen-specific awareness (Bou-Mitri et al., 2018). The detailed results of respondents' food safety knowledge are presented in Table 1.

However, knowledge is not always evenly distributed across all areas of food safety. In Indonesia, food handlers scored well in general hygiene knowledge (M = 4.10), but exhibited lower familiarity with specific pathogens such as Salmonella typhi (M = 2.27) and *Staphylococcus aureus* (M = 2.40) (Putri and Susanna, 2021). Likewise, only 42.3% of food handlers in Ghana knew the correct method for cleaning utensils used for raw meat, and just 56.2% could correctly identify the proper storage method for fresh meat (Tuglo et

al., 2021). In Kuwait, Al-Kandari et al. (2019) similarly reported that while general safety practices were well understood, there were significant deficits in microbial hazard recognition.

Table 1: Food safety knowledge

Statements	Mean	Verbal description
1. Hands must be washed thoroughly with soap before handling food.	4.53	Very high knowledge
2. The best way to thaw meat is by using the microwave or refrigerator.	3.31	Moderate knowledge
3. Bacteria are kept from spreading in the kitchen when raw chicken is cooked without being cleaned.	3.36	Moderate knowledge
4. Hands must still be washed even when wearing gloves.	4.46	Very high knowledge
5. Foodborne illness can be prevented by checking expiration dates before consuming or using packaged/canned food.	4.44	Very high knowledge
6. Dirt and bacteria are eliminated when fruits and vegetables are washed under clean running water.	4.57	Very high knowledge
7. Foods that are cooked or ready to eat should be kept apart from raw meat.	4.33	Very high knowledge
8. Cross-contamination can be avoided by keeping raw meat and vegetables on different cutting boards and knives.	3.83	High knowledge
9. Leftovers must be thoroughly reheated before being consumed.	4.22	Very high knowledge
10. Food contamination is less likely when people practice good personal hygiene.	4.61	Very high knowledge
Overall mean	4.17	High knowledge

Education and training have consistently been associated with stronger food safety knowledge. In Ethiopia, food handlers who had completed secondary education or received food safety training exhibited significantly greater knowledge compared to those who had not (Alemayehu et al., 2021). In Morocco, food handlers involved in collective catering services who underwent training demonstrated a more advanced understanding of contamination risks and proper storage techniques (Amaiach et al., 2024). In contrast, most food handlers in Pakistan had not received formal training, with only 5.9% attending certified programs—a factor contributing to persistent knowledge gaps (Ahmed et al., 2021). Similarly, a study in Metro Manila found that food handlers who had undergone training displayed markedly higher awareness of microbial contamination and sanitation protocols. These findings reinforce the critical role of structured education and regular retraining in promoting comprehensive food safety knowledge, especially in pathogen awareness and technical handling procedures. The respondents demonstrated a strong and positive attitude toward food safety, reflecting awareness of hygienic practices and a sense of responsibility in maintaining safe food environments. Most participants agreed that food safety is a shared responsibility and that adherence to safety regulations is essential even when time-consuming. These findings suggest that positive attitudes may support compliance with institutional food safety standards. As shown in Table 2, respondents reported very positive attitudes toward food safety practices. This is consistent with prior findings, where school food handlers in Ghana showed high agreement with key safety behaviors—for instance, 92.6% supported disposing of expired food, and 87.2% endorsed separating raw and cooked meals (Tuglo et al., 2021). These attitudes play a critical role in ensuring the successful implementation of food safety protocols, as individuals are more likely to follow procedures they believe in. Similar positive attitudes were reported among Lebanese hospital food handlers, where staff generally agreed with the importance of food hygiene, even if gaps in actual behavior remained (Bou-Mitri et al., 2018). Favorable attitudes thus serve as an important foundation for cultivating a food-safe environment in institutional and public settings.

Table 2: Food safety attitudes

Statements	Mean	Verbal description
1. I think it's crucial for everyone to abide by food safety regulations.	4.10	Positive attitude
2. I have faith in my ability to adhere to food safety regulations.	4.51	Very positive attitude
3. Even if following food safety regulations takes more time, I think they should always be done.	4.14	Positive attitude
4. Food safety, in my opinion, is a shared responsibility between consumers and food handlers.	4.02	Positive attitude
5. I'm concerned about how hygienic the food served in public or at school is.	3.67	Positive attitude
6. I appreciate that university canteens take precautions to ensure food safety.	4.75	Very positive attitude
7. In my opinion, food preparation should always include proper hygiene.	4.69	Very positive attitude
8. I think it's critical to educate consumers and food handlers about food safety.	3.91	Positive attitude
9. I believe it is my personal duty to prepare and consume food in a safe manner.	4.66	Very positive attitude
10. I'm prepared to put in the time necessary to guarantee that food is handled safely.	4.53	Very positive attitude
Overall mean	4.30	Very positive attitude

However, positive attitudes are not always paired with accurate knowledge or safe behavior. In Indonesia, nearly 47.2% of food handlers believed it was acceptable to store raw materials and leftovers in the same refrigerator, a misconception that may contribute to cross-contamination (Putri and Susanna, 2021). Likewise, in Ghana, 44.5% of handlers relied solely on food appearance to assess spoilage, overlooking the fact that many pathogens are undetectable through sight or smell (Tuglo et al., 2021). Similar issues were identified in Morocco, where certain attitudes were rooted in routine rather than evidence-based practices, emphasizing the risk of complacency (Amaiach et al., 2024). These findings highlight the importance of critically evaluating food safety attitudes to ensure they are grounded in valid, science-based practices rather than habits or cultural norms.

Moreover, the development and reinforcement of food safety attitudes are influenced by external factors such as workload, time constraints, and access to continuing education. In Indonesia, 56.9% of food handlers expressed reluctance to attend food safety training due to time limitations, potentially impeding the reinforcement of sound attitudes (Putri and Susanna, 2021). In Brazil, some food handlers reported positive attitudes not out of genuine conviction but likely due to social desirability bias—suggesting that attitudes alone may not reliably predict safe behavior (da Vitória et al., 2021). Similarly, food handlers in Pakistan demonstrated moderate attitudes overall, though many lacked formal training, affecting the authenticity and depth of their food safety perspectives (Ahmed et al., 2021). These insights underscore the importance of context-specific, experiential training approaches and regular supervision to ensure that positive attitudes are internalized and ultimately translated into consistent and safe food handling behaviors.

Respondents in the study demonstrated good to excellent food safety practices, such as regular handwashing, separation of raw and cooked foods, and cleaning of food contact surfaces. These findings align with prior research in Ghana, where 84.3% of food handlers reported washing their hands during meal preparation, 91.4% washed fresh, non-cooked foods before use, and 78.4% cleaned kitchen tools before reuse (Tuglo et al., 2021). Similarly, in the Philippines, food handlers showed high compliance with hygiene-related practices, including food storage and control, contributing to an average practice score of 84.3%. In Kuwait, practices related to personal hygiene were especially strong (82%), but weaknesses were still noted in areas like cross-contamination prevention and temperature control (Al-Kandari et al., 2019). As shown in Table 3, respondents generally demonstrated good to excellent food safety practices.

Despite these encouraging self-reported behaviors, discrepancies between claimed and actual practices have been frequently observed. Social desirability bias often leads food handlers to report safer behaviors than they truly perform (da Vitória et al., 2021). For example, in Ghana, 62.2% of handlers reported using the same cloth to clean both hands and surfaces, and 68.3% left cooked food at room temperature for over two hours, increasing the risk of contamination (Tuglo et al., 2021). This phenomenon is not isolated; in Lebanon, the most frequently reported incorrect behavior was thawing food at room temperature (72.8%), highlighting the persistence of unsafe practices even in institutional food settings (Bou-Mitri et al., 2018).

Table 3: Food safety practices

Statements	Mean	Verbal description
1. Before I eat or prepare food, I wash my hands.	4.55	Excellent practices
2. Before consuming packaged food, I always make sure to check the expiration date.	3.80	Good practices
3. Before consuming or preparing any fruits or vegetables, I wash them.	4.48	Excellent practices
4. When I'm cooking, I keep the raw and cooked ingredients apart.	4.38	Excellent practices
5. I keep my kitchen hygienic by routinely cleaning its surfaces.	4.70	Excellent practices
6. After every use, I sanitize and clean kitchenware like knives and boards.	3.84	Good practices
7. If I'm not feeling well, I don't handle or prepare food.	3.36	Moderate practices
8. I try not to keep cooked food out at room temperature for too long.	3.32	Moderate practices
9. When I serve food to other people, I wear gloves or utensils.	4.59	Excellent practices
10. As soon as I purchase or use perishable goods, I put them in the refrigerator.	4.34	Excellent practices
Overall mean	4.14	Good practices

Infrastructural constraints also play a significant role. In Indonesia, 51.4% of food handlers washed their hands without soap due to limited access to sanitation facilities (Putri and Susanna, 2021). These systemic limitations often make it difficult for handlers to translate knowledge and intentions into consistent, safe actions. Findings from Morocco further underscore the impact of demographic and contextual factors on practices—education level, job type, and marital status all influenced compliance with food safety protocols (Amaiach et al., 2024).

Nonetheless, training and supervision continue to prove effective. In Ethiopia, institutional cafeterias that implemented hands-on training and close monitoring experienced marked improvements in safe food handling (Alemayehu et al., 2021). Positive correlations have been observed between training and safe practices in multiple settings, including hospitals in Metro Manila, restaurants in Kuwait (Al-Kandari et al., 2019), and collective catering operations in Morocco (Amaiach et al., 2024). These studies reinforce the necessity of continuous education that goes beyond theory, emphasizing practical, supervised application to embed food safety deeply into daily routines.

3.2. Food pathogen awareness

The results of the food pathogen awareness survey reveal a mixed but generally encouraging level of awareness among university canteen food handlers, with an overall mean score of 3.38, categorized as high awareness. Several items in the questionnaire demonstrated very high awareness, particularly those concerning general knowledge about the nature and transmission of foodborne illnesses. Respondents strongly agreed that good hygiene and handwashing can prevent the spread of foodborne diseases (M = 4.83), that dangerous bacteria can cause life-threatening illnesses (M = 4.75), and that proper cooking and storage can help eliminate or inhibit microbial growth (M = 4.70). Similarly, there was high awareness that pathogens are often invisible, odorless, and tasteless (M = 4.15),

and that bacteria, viruses, and parasites are common culprits of foodborne illnesses (M = 4.07). These findings reflect broader global trends where general food safety concepts are well understood among food handlers (Angelillo et al., 2000; Altekruse et al., 1996). As shown in Table 4, respondents demonstrated high overall awareness of foodborne pathogens.

Table 4: Food pathogen awareness

Statements	Mean	Verbal description
1. I am aware that dangerous bacteria in food can result in life-threatening illnesses.	4.75	Very high awareness
2. I am aware that foodborne illnesses are frequently brought on by bacteria, viruses, and parasites.	4.07	High awareness
3. I am aware that maintaining good hygiene and handwashing can help stop the spread of foodborne illnesses.	4.83	Very high awareness
4. I am aware that the majority of foodborne pathogens are invisible, odorless, and tasteless.	4.15	High awareness
5. I am aware that cooking and storing food properly can either eliminate or inhibit the growth of dangerous microorganisms.	4.70	Very high awareness
6. I am aware that undercooked meat, poultry, and raw eggs are common sources of Salmonella.	3.27	Moderate awareness
7. I am aware that undercooked beef and tainted produce can contain *E. coli*.	2.22	Low awareness
8. I am aware that even chilled foods, such as soft cheeses and cold cuts, can harbor Listeria.	1.91	Low awareness
9. I am aware that Campylobacter is a prevalent bacterium that can be found in raw or undercooked chicken.	2.07	Low awareness
10. I am aware that contact with infected surfaces, tainted food, or water can all spread the norovirus.	1.78	Very low awareness
Overall mean	3.38	High awareness

Despite these encouraging results in general microbial safety concepts, the study found marked deficiencies in awareness of specific pathogens. Awareness of Salmonella as a risk from undercooked poultry and raw eggs scored only moderately (M = 3.27). Even more concerning were the low awareness levels regarding *Escherichia coli* (M = 2.22) and Campylobacter (M = 2.07), both of which are commonly associated with undercooked or contaminated foods. The awareness of Listeria was similarly low (M = 1.91). Awareness of norovirus was also very low (M = 1.78), marking the lowest score among all items.

These results suggest a critical gap between general food safety concepts and specific pathogen recognition. While respondents show a strong grasp of foundational hygiene principles and disease prevention strategies, their limited awareness of high-risk pathogens indicates the need for more targeted and pathogen-specific education. This is consistent with the findings of Putri and Susanna (2021) and Tuglo et al. (2021), who reported that while food handlers demonstrated high general knowledge, their familiarity with specific pathogens such as Salmonella typhi and *Staphylococcus aureus* was notably poor.

Moreover, Madilo et al. (2023) emphasized that pathogen awareness is significantly influenced by demographic factors such as level of study, educational background, and exposure to food safety education. In their study, although students in Ghana were generally aware of Salmonella typhimurium (53.5%) and *Staphylococcus aureus* (53.4%), awareness of other foodborne pathogens remained low, and significant differences were observed based on respondents' field and level of study. Similarly, Al-Mohaithef (2021) found that only 34.5% of students in Saudi Arabia were aware of major foodborne pathogens, with those in health-related fields demonstrating significantly higher awareness compared to others.

The role of sociodemographic characteristics in shaping pathogen knowledge was further supported by Al Banna et al. (2022), who found that sex, age, and education were strongly associated with awareness among consumers of street-vended food. In line with this, the present study suggests the necessity of tailoring food safety education programs to the specific backgrounds of food handlers, especially in institutional settings such as university canteens.

Altekruse et al. (1996) and Angelillo et al. (2000) have long argued that microbiological literacy—especially regarding the link between specific pathogens and food vehicles—is crucial for safe food handling practices. However, this form of literacy is often lacking. Angelillo et al. (2000) reported that only 7.1% of food handlers in Italy could correctly identify five food vehicles linked to five common pathogens, despite reporting high levels of general food safety knowledge. This aligns with the current study's findings that emphasize the need for targeted education on high-risk microorganisms.

Improving awareness of pathogens such as Listeria, Campylobacter, and norovirus is essential for strengthening institutional food safety systems. Without a clear understanding of these pathogens, food handlers may rely on visual cues or habits that are not scientifically sound. Thus, training programs must emphasize not only hygiene and sanitation but also the biological risks posed by specific microorganisms (Putri and Susanna, 2021; Al Banna et al., 2022; Madilo et al., 2023).

3.3. Microbial contamination

To evaluate the microbial safety of food and work surfaces in the canteens of a higher education institution, a total of five categories of samples—drinks, meals, frozen foods, tables, and utensils—were analyzed for the presence of *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus cereus*. All tested items yielded microbial counts that were within the microbiologically acceptable thresholds and were thus interpreted as satisfactory based on internationally recognized standards (Gilbert et al., 2000). As shown in Table 5, all sampled food items and contact surfaces were microbiologically satisfactory.

Table 5: Microbial contamination

Food safety	*S. aureus*	*E. coli*	*B. cereus*	Interpretation
Drinks	20 CFU/ml	10 CFU/ml	Not detected	Satisfactory
Meals	10 CFU/g	3 CFU/g	10 CFU/g	Satisfactory
Prepared frozen food	10 CFU/g	Not detected	90 CFU/g	Satisfactory
Tables	Not detected	1 CFU/cm^2	Not detected	Satisfactory
Utensils	Not detected	Not detected	Not detected	Satisfactory

Staphylococcus aureus was detected in drinks (20 CFU/ml), meals (10 CFU/g), and frozen foods (10 CFU/g). Despite the detection, all values remained within the defined satisfactory limits of prescribed standards (Gilbert et al., 2000). *Escherichia coli* was detected in drinks (10 CFU/ml), meals (3 CFU/g), and on tables (1 CFU/cm^2), but was absent in frozen foods and utensils. All values remained below the <20 CFU threshold for food and drink (Gilbert et al., 2000), and the surface result complied with the benchmark of <1 CFU/cm^2 for contact surfaces.

Bacillus cereus was found in meals (10 CFU/g) and frozen foods (90 CFU/g), with concentrations well below the acceptable limit of <1000 CFU/g (Gilbert et al., 2000). The relatively higher count in frozen foods suggests possible temperature control issues during storage or handling. Although the levels remain within satisfactory bounds, this reinforces the need for stringent cold chain management, especially for starchy foods prone to B. cereus growth (Osimani et al., 2011).

No microorganisms were detected in utensils, and only minimal *E. coli* was found on table surfaces. The absence of microbial contaminants on utensils indicates effective cleaning and handling practices, while the minor detection on tables suggests a need to review surface sanitation protocols.

These findings collectively affirm that the food safety practices in place are largely effective, although the occasional presence of microorganisms highlights areas for continued improvement. Routine microbial surveillance, reinforcement of hygiene practices, and targeted training for food handlers remain essential in sustaining microbiological quality and minimizing contamination risks in institutional food service environments (Osimani et al., 2011). These findings highlight that sustaining low contamination levels depends not only on individual food handler behavior but also on institutional governance, performance management, and quality assurance mechanisms that support consistent implementation of safety standards (De Lara and Santos, 2024; De Leon and Santos, 2025).

3.4. Relationship between food safety and pathogen awareness

The relationship between food safety knowledge and food pathogen awareness among food handlers revealed a moderate, positive, and statistically significant correlation ($r = 0.428$, $p < 0.001$). This suggests that as food handlers' knowledge regarding food safety increases, so does their awareness of foodborne pathogens. The strength of this association implies that a foundational understanding of safety protocols—such as correct storage temperatures, cross-contamination prevention, and hygiene practices—plays a crucial role in enhancing handlers' cognitive recognition of specific microbial threats like Salmonella, *E. coli*, and Listeria. These results support the idea that knowledge acquisition is a primary driver of risk perception and cognitive alertness toward pathogenic contamination. This underscores the value of integrating detailed microbiological education into food safety training modules to improve awareness and proactive behavior among handlers in institutional food service settings. As shown in Table 6, food safety knowledge was significantly positively correlated with pathogen awareness.

Table 6: Relationship between food safety and pathogen awareness

Food safety		Pathogen awareness
Food safety knowledge	r – value	0.428
	p – value	0.000
Food safety attitudes	r – value	0.416
	p – value	0.000
Food safety practices	r – value	0.446
	p – value	0.000

The data also show a statistically significant, moderate positive correlation between food safety attitudes and food pathogen awareness ($r = 0.416$, $p < 0.001$). While the strength of this relationship is slightly lower than that of knowledge, it indicates that the more positive and responsible a food handler's disposition is toward safety protocols, the greater their awareness of pathogen-related risks. This highlights the influence of internal motivation, beliefs, and value systems in shaping awareness. Attitudes encompass an individual's sense of accountability, moral obligation, and perceived importance of following best practices, all of which are crucial for fostering an environment of vigilance and caution. Positive attitudes likely encourage food handlers to seek information and stay updated on pathogenic threats, thereby supporting continuous learning and heightened awareness. These findings affirm that attitudinal shifts are just as essential as cognitive knowledge in developing a safety-conscious food service workforce.

Among the three variables examined, food safety practices demonstrated a moderate positive correlation with food pathogen awareness ($r = 0.446$, $p < 0.001$), suggesting a close link between actual behaviors and the level of microbial risk awareness among food handlers. This implies that those who consistently implement proper food handling procedures—such as routine handwashing, appropriate cooking temperatures, and sanitation of work areas—are also more alert to the dangers posed by foodborne pathogens. The act of engaging

in correct practices may serve as experiential reinforcement, making the invisible threat of pathogens more tangible through habitual precautions. Additionally, this relationship suggests a reciprocal dynamic: not only does awareness likely motivate safe practices, but consistent implementation of safety measures may also enhance one's recognition of why such practices are necessary. Therefore, training interventions should not only convey knowledge and promote positive attitudes but also focus on skill-building and habit formation to cultivate a culture of safety and awareness in food service institutions.

Taken together, the findings indicate a paradox: while general food safety knowledge and attitudes are high, awareness of specific pathogens such as *E. coli*, Listeria, Campylobacter, and norovirus remains low, which may explain why microbial contamination is controlled but not eliminated.

3.5. Relationship between pathogen awareness and microbial presence

The relationship between food pathogen awareness and microbial presence in the canteens of a higher education institution in Nueva Ecija yielded a weak but statistically significant negative correlation ($r = -0.246$, $p = 0.001$). This result indicates that as the level of pathogen awareness among food handlers increases, the presence of microbial contaminants in the food environment tends to decrease. Although the strength of the correlation is modest, the negative direction is meaningful: it suggests that greater awareness of foodborne pathogens may lead to more cautious and hygienic behavior, thereby reducing opportunities for microbial contamination. The statistical results of this relationship are presented in Table 7. Awareness likely influences vigilance in implementing preventive measures such as thorough cleaning, correct food storage, and proper cooking techniques, all of which contribute to a cleaner and safer food service environment. The statistically significant p-value further validates this finding, affirming that the observed relationship is unlikely due to chance. This underscores the importance of educational and awareness campaigns focused on foodborne pathogens, not only to raise knowledge levels but also to drive measurable reductions in contamination risks within institutional food settings.

Table 7: Relationship between pathogen awareness and microbial presence

		Microbial presence
Pathogen awareness	r – value	-0.246
	p – value	0.001

3.6. Relationship between food safety and microbial presence

The analysis revealed a statistically significant negative correlation between food safety knowledge and microbial presence in canteen environments ($r = -0.327$, $p = 0.033$). This finding suggests that as food handlers' knowledge about food safety increases, the level of microbial contamination in food preparation areas tends to decrease. The moderate strength of this inverse relationship implies that a more comprehensive understanding of food safety principles—such as critical control points, contamination routes, and proper sanitation—can effectively translate into behaviors and precautions that reduce microbial risks. Knowledge empowers food handlers to identify and eliminate contamination sources, demonstrating its preventive potential. The statistically significant p-value further supports the reliability of this association, emphasizing the need to integrate thorough food safety education in training programs to mitigate contamination in institutional food service operations. The statistical relationship between pathogen awareness and microbial presence is presented in Table 8.

Table 8: Relationship between food safety and microbial presence

Food safety		Microbial presence
Food safety knowledge	r – value	-0.327
	p – value	0.033
Food safety attitudes	r – value	-0.309
	p – value	0.042
Food safety practices	r – value	-0.342
	p – value	0.031

A statistically significant negative correlation was also found between food safety attitudes and microbial presence ($r = -0.309$, $p = 0.042$), indicating that more positive attitudes toward food safety are associated with reduced microbial contamination. This relationship, although slightly weaker than that observed with knowledge, underscores the importance of mindset and motivation in food handling practices. Attitudes reflect the internalization of safety values and personal commitment to hygienic standards. Food handlers who view food safety as essential are more likely to act conscientiously, even in the absence of supervision, and their commitment can contribute to a cleaner, safer environment. The statistical significance of the p-value confirms that this association is not incidental, suggesting that behavioral interventions and attitude-focused awareness efforts should be prioritized in food safety programs.

Among the three variables, food safety practices showed the strongest negative correlation with microbial presence ($r = -0.342$, $p = 0.031$), indicating that better safety practices are significantly associated with lower levels of microbial contamination in canteen settings. This suggests that hands-on, practical behaviors—such as correct hand hygiene, consistent cleaning and sanitization, safe food storage, and proper handling techniques—have the most direct and measurable impact on microbial presence. This relationship emphasizes the critical role of translating knowledge and attitudes into

habitual actions that prevent contamination. The significance of the p-value affirms the robustness of this finding and supports the notion that targeted behavioral training, regular performance monitoring, and reinforcement of safe food practices are essential strategies to reduce microbial hazards in institutional kitchens. As such, programs that not only educate but also train and reinforce food safety practices can lead to significant improvements in food hygiene and public health outcomes.

4. Conclusion

This study assessed the food safety knowledge, attitudes, practices, and pathogen awareness of food handlers in a higher education institution, alongside an evaluation of microbial contamination in canteen food and contact surfaces. Overall, food handlers exhibited high levels of food safety knowledge and very positive attitudes, with good to excellent self-reported practices in key areas such as handwashing, separation of raw and cooked foods, surface cleaning, and cold storage. Pathogen awareness was also generally high for basic concepts related to foodborne illnesses and prevention strategies. However, the results revealed notable gaps in awareness of specific high-risk pathogens, particularly *Escherichia coli*, *Campylobacter*, *Listeria* spp., and norovirus, which received low to very low mean scores despite their established role in foodborne disease outbreaks. Microbiological analyses confirmed that contamination levels in drinks, meals, frozen foods, tables, and utensils were within satisfactory limits, yet the detection of *Staphylococcus aureus*, *E. coli*, and *Bacillus cereus* in some samples indicates that lapses in hygiene, sanitation, and cold chain management still pose potential risks. Correlational analyses further demonstrated that higher food safety knowledge, more positive attitudes, and better reported practices were significantly associated with greater pathogen awareness and lower microbial presence in the canteen environment. These findings underscore the practical value of strengthening food safety literacy and behavioral adherence to reduce contamination risks in institutional food service settings. Considering these results, the following recommendations are proposed:

1. Implement targeted, pathogen-specific training. Food safety training programs should move beyond general hygiene and incorporate focused instruction on high-risk pathogens for which awareness was low in this study, particularly *L. monocytogenes*, norovirus, *Campylobacter*, and pathogenic *E. coli*. Training modules should emphasize their common food vehicles (e.g., chilled ready-to-eat foods, undercooked meats, contaminated produce) and specific prevention strategies.
2. Institutionalize periodic training and certification. Regular food safety training and certification should be made mandatory for all institutional food handlers to reinforce essential practices and update them on evolving risks, including emerging pathogens and changes in food safety regulations. Refresher training should be aligned with identified gaps in knowledge, attitudes, practices, and pathogen awareness.
3. Strengthen supervision, monitoring, and microbial surveillance. Regular supervision and performance monitoring should be implemented through routine microbial assessments of food and contact surfaces, observational audits of food handling behaviors, and on-site hygiene inspections. Attention should be given to cold chain management and handling of frozen or starchy foods, considering the *B. cereus* counts observed in prepared frozen items.
4. Ensure adequate infrastructure and hygiene facilities. The institution should guarantee the availability and proper maintenance of basic facilities such as handwashing stations with soap, reliable refrigeration and freezer units, and appropriate cleaning and sanitizing equipment. These facilities are essential to support consistent application of safe food handling practices and to sustain the satisfactory microbial profile observed in most samples.
5. Promote food safety as a shared institutional responsibility. Food safety should be framed and operationalized as a shared responsibility among food handlers, canteen managers, administrators, and consumers. Policies, communication campaigns, and institutional support mechanisms should encourage a culture of accountability in which all stakeholders recognize their role in maintaining safe food environments.
6. Pursue further research with multivariate approaches. Future studies with larger and more diverse samples are encouraged to apply multivariate techniques (e.g., multiple regression or structural equation modelling) to more precisely identify which dimensions of food safety knowledge, attitudes, and practices most strongly predict pathogen awareness and microbial contamination levels. Such analyses would deepen understanding of the mechanisms linking human factors and microbiological outcomes in institutional food service settings.

Integrating microbiological monitoring with behavioral assessment and targeted interventions, higher education institutions can strengthen their food safety systems, reduce contamination risks, and protect the health of their campus communities.

Compliance with ethical standards

Ethical considerations

This study involved human participants and adhered to established ethical standards for research involving human subjects. Participation in the survey was voluntary, and informed consent was obtained from all respondents prior to data collection.

Participants were informed of the purpose of the study, the confidentiality of their responses, and their right to withdraw at any time without penalty. No personally identifiable information was collected, and all data were treated with strict confidentiality and used solely for research purposes. The study protocol was reviewed and approved by the appropriate institutional authority in accordance with ethical research guidelines.

Conflict of interest

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

References

Ahmed MH, Akbar A, and Sadiq MB (2021). Cross sectional study on food safety knowledge, attitudes, and practices of food handlers in Lahore district, Pakistan. Heliyon, 7(11): e08420. https://doi.org/10.1016/j.heliyon.2021.e08420 **PMid:34841116 PMCid:PMC8606342**

Al Banna MH, Kundu S, Brazendale K, Ahinkorah BO, Disu TR, Seidu AA, Okyere J, and Khan MSI (2022). Knowledge and awareness about food safety, foodborne diseases, and microbial hazards: A cross-sectional study among Bangladeshi consumers of street-vended foods. Food Control, 134: 108718. https://doi.org/10.1016/j.foodcont.2021.108718

Alemayehu T, Aderaw Z, Giza M, and Diress G (2021). Food safety knowledge, handling practices and associated factors among food handlers working in food establishments in Debre Markos Town, Northwest Ethiopia, 2020: Institution-based cross-sectional study. Risk Management and Healthcare Policy, 14: 1155-1163. https://doi.org/10.2147/RMHP.S295974 **PMid:33762858 PMCid:PMC7982701**

Al-Kandari D, Al-Abdeen J, and Sidhu J (2019). Food safety knowledge, attitudes and practices of food handlers in restaurants in Kuwait. Food Control, 103: 103-110. https://doi.org/10.1016/j.foodcont.2019.03.040

Al-Mohaithef M (2021). Awareness of foodborne pathogens among students: A cross-sectional study in the Kingdom of Saudi Arabia. International Journal of Food Science, 2021: 9971748. https://doi.org/10.1155/2021/9971748 **PMid:34095294 PMCid:PMC8164529**

Altekruse SF, Street DA, Fein SB, and Levy AS (1996). Consumer knowledge of foodborne microbial hazards and food-handling practices. Journal of Food Protection, 59(3): 287-294. https://doi.org/10.4315/0362-028X-59.3.287 **PMid:10463448**

Amaiach R, Lalami AEO, Fadil M, Bouslamti R, and Lairini S (2024). Food safety knowledge, attitudes, and practices among food handlers in collective catering in central Morocco. Heliyon, 10(23): e40739. https://doi.org/10.1016/j.heliyon.2024.e40739 **PMid:39687091 PMCid:PMC11648122**

Angelillo IF, Viggiani NM, Rizzo L, and Bianco A (2000). Food handlers and foodborne diseases: Knowledge, attitudes, and reported behavior in Italy. Journal of Food Protection, 63(3): 381-385. https://doi.org/10.4315/0362-028X-63.3.381 **PMid:10716569**

Bou-Mitri C, Mahmoud D, El Gerges N, and Abou Jaoude M (2018). Food safety knowledge, attitudes and practices of food handlers in Lebanese hospitals: A cross-sectional study. Food Control, 94: 78-84. https://doi.org/10.1016/j.foodcont.2018.06.032

da Vitória AG, de Souza Couto Oliveira J, de Almeida Pereira LC, de Faria CP, and de São José JFB (2021). Food safety knowledge, attitudes and practices of food handlers: A cross-sectional study in school kitchens in Espírito Santo, Brazil. BMC Public Health, 21: 349. https://doi.org/10.1186/s12889-021-10282-1 **PMid:33579231 PMCid:PMC7881630**

De Lara MGO and Santos AR (2024). Service delivery and quality assurance in administrative units of higher education institutions during the pandemic. Corporate and Business Strategy Review, 5(1): 494–504. https://doi.org/10.22495/cbsrv5i1siart22

De Leon CL and Santos AR (2025). Consumer profile and rabbit meat preferences: Analyzing marketability and acceptance using the 4A's model of marketing. Research on World Agricultural Economy, 6(1): 702-716. https://doi.org/10.36956/rwae.v6i1.1651

Gamit AM, Santos AR, Armas KL, and Villegas MN (2024). Implementation of ISO 9001: 2015 in state universities and colleges: A quality management, organizational performance, and legal framework. Corporate Law & Governance Review, 6(4): 94–102. https://doi.org/10.22495/clgrv6i4p9

Gilbert RJ, De Louvois J, Donovan T, Little C, Nye K, Ribeiro CD, Richards J, Roberts D, and Bolton FJ (2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale: PHLS advisory committee for food and dairy products. Communicable Disease and Public Health, 3(3): 163-167.

Grace D (2015). Food safety in low and middle income countries. International Journal of Environmental Research and Public Health, 12(9): 10490-10507. https://doi.org/10.3390/ijerph120910490 **PMid:26343693 PMCid:PMC4586623**

Jacoba FP, Santos AR, Armas KL, and Gamit AM (2024). A comprehensive analysis of a science and technology university's alignment with the performance excellence framework: A governance outlook study. Journal of Governance & Regulation, 13(3): 213-223. https://doi.org/10.22495/jgrv13i3art18

Madilo FK, Islam MN, Letsyo E, Roy N, Klutse CM, Quansah E, Darku PA, and Amin MB (2023). Foodborne pathogens awareness and food safety knowledge of street-vended food consumers: A case of university students in Ghana. Heliyon, 9(7): e17795. https://doi.org/10.1016/j.heliyon.2023.e17795 **PMid:37483828 PMCid:PMC10359811**

Odeyemi OA and Bamidele FA (2016). Harnessing the potentials of predictive microbiology in microbial food safety and quality research in Nigeria. Future Science OA, 2(1): FSO91. https://doi.org/10.4155/fso.15.91 **PMid:28031941 PMCid:PMC5137888**

Osimani A, Aquilanti L, Babini V, Tavoletti S, and Clementi F (2011). An eight-year report on the implementation of HACCP in a university canteen: Impact on the microbiological quality of meals. International Journal of Environmental Health Research, 21(2): 120-132. https://doi.org/10.1080/09603123.2010.515669 **PMid:21424969**

Putri MS and Susanna D (2021). Food safety knowledge, attitudes, and practices of food handlers at kitchen premises in the Port 'X' area, North Jakarta, Indonesia 2018. Italian Journal of Food Safety, 10(4): 9215. https://doi.org/10.4081/ijfs.2021.9215 **PMid:35018288 PMCid:PMC8672317**

Ramos FG and Despojo AG (2025). Food safety knowledge, attitudes, and practices of school canteen food handlers in the District of Maria, Siquijor, Philippines. Journal of Interdisciplinary Perspectives, 3(3): 331-341. https://doi.org/10.69569/jip.2024.0586

Reyes MCP (2020). Assessment of Food Safety and Sanitation Standards of Canteens in Nueva Ecija. International Journal of

Advanced Engineering, Management and Science, 6(1): 34-36. https://doi.org/10.22161/ijaems.61.5

Tuglo LS, Agordoh PD, Tekpor D, Pan Z, Agbanyo G, and Chu M (2021). Food safety knowledge, attitude, and hygiene practices of street-cooked food handlers in North Dayi District, Ghana. Environmental Health and Preventive Medicine, 26: 54. https://doi.org/10.1186/s12199-021-00975-9 **PMid:33941082 PMCid:PMC8091506**