Pertiwi et al | Article 9956
J Pure Appl Microbiol. 2025;19(2):1350-1357. doi: 10.22207/JPAM.19.2.38
Received: 04 October 2024 | Accepted: 14 March 2025
Published Online: 02 June 2025

P-ISSN: 0973-7510; E-ISSN: 2581-690X

RESEARCH ARTICLE OPEN ACCESS

Assessing the Relationship Between Food Safety Behaviour and *Escherichia coli* Contamination from Uncertified School Catering Services

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Abstract

Food safety is an important issue in the school environment, especially by food handlers responsible for providing lunches to students, who are vulnerable to foodborne diseases. This cross-sectional study assessed the demographic characteristics of food handlers, including food safety-related knowledge and behaviour, and their impact on *Escherichia coli* bacterial contamination on their hands. Data were collected from 88 foodservice workers in 6 selected schools from a structured questionnaire and a hand swab test. The results showed that 39.8% of the food handlers had good knowledge and 38.6% implemented good food safety practices. These findings are significant, considering that 10.2% of food handlers tested positive for *Escherichia coli,* which can be fatal to the health of vulnerable students. Further statistical analyses identified a significant relationship between food handler behaviour and *Escherichia coli* contamination (p = 0.031), although no significant relationship with knowledge level was determined (p = 0.135). This study underscores the importance of food safety training for non-certified food handlers in internal school catering services. These results also provide a knowledge basis for policymakers and schools regarding taking immediate preventive measures to maintain the health and safety of students.

Keywords: Food Safety, Food Handlers, *Escherichia coli*, School

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Citation: Pertiwi SMB, Denny HM, Nurjazuli N, Mustofa SB. Assessing the Relationship Between Food Safety Behaviour and *Escherichia coli* Contamination from Uncertified School Catering Services. *J Pure Appl Microbiol.* 2025;19(2):1350-1357. doi: 10.22207/JPAM.19.2.38

INTRODUCTION

Foodborne diseases are a global health problem that has a significant impact.[1] According to the World Health Organization, approximately 600 million cases of foodborne illnesses are reported each year globally, indicating that 1 in 10 people experience foodborne diseases.[2] In Indonesia, food safety remains a critical public health concern. According to the Indonesian Agency of Drug and Food Control (BPOM), 2,442 cases of food poisoning were reported in 2023 based on national surveillance data.[3] These diseases are caused by the consumption of food contaminated with various microorganisms, including bacteria, viruses, parasites, fungi, chemicals, natural toxins, and physical hazards present in food.[4] This problem of contamination is exacerbated in the non-certified catering sector, where sanitation practices and food safety standards are often ignored.[5]

Biological hazards, especially pathogenic bacteria such as *Escherichia coli* (*E. coli*), *Salmonella, Campylobacter*, and *Listeria*, are the main cause of foodborne diseases.[4] *E. coli* is one of the bacteria that is often found in contaminated food, especially in uncertified or poorly supervised catering services.[6] These bacteria can cause serious illnesses such as vomiting, kidney damage, and death in severe cases. This condition not only affects individual health but also significantly impacts public health and economic burdens, particularly in developing countries where food security is often inadequate. Food contamination has become increasingly worrisome because many catering services, including those in schools, have not met adequate food safety standards, which can potentially increase the burden on public health. Students have a high level of dependence on food provided by schools.[5] In addition, students are a vulnerable group at risk of exposure to foodborne illnesses owing to their immune systems that are not fully developed.[7]

Food handlers in schools have an important role in maintaining food safety. However, poor knowledge and behaviour that do not comply with hygiene standards will result in the risk of bacterial contaminations, such as *E. coli*, potential disease outbreaks among students.[8] This condition not only impacts the health of individuals but also the overall school environment, which can exacerbate the public health and economic burden in developing countries such as Indonesia, where food security systems are often suboptimal.

Previous research has mostly focused on food handlers in more structured sectors such as school canteens,[9] hospitals,[10] and restaurants,[11] where stricter food safety standards are applied. However, research exploring the practice of food handlers in uncertified internal school catering services is very limited. Therefore, in-depth studies that evaluate and improve the knowledge and behaviour of food handlers in the sector, as well as identify the factors that contribute to food contamination are warranted.

This study aimed to fill the gap in the research by evaluating the demographic characteristics of non-certified school catering food handlers, their knowledge level about food safety, and the relationship between their knowledge level and behaviour and the presence of *E. coli* pathogenic bacteria on their hands. The results of this study are expected to provide a basis for the development of more effective training programs and interventions to improve food safety in schools.

MATERIALS AND METHODS

Study design

This cross-sectional study assessed the demographic characteristics, knowledge, and behaviour of food handlers related to food safety when providing lunch to students. In addition, the relationships between these factors and *E. coli* contamination on the hands of food handlers was evaluated.

Sample and population

This study was conducted in 6 schools that had internal catering services without formal certification in Semarang City, Indonesia. The study population comprised all food handlers who worked in the schools' internal catering services. From this population, 88 food handlers were selected as research participants using the purposive sampling technique. This participant sample was considered representative of the food handlers in the schools' internal catering services.

Data collection

Data were collected using a structured questionnaire and a swab test. Demographic information (age, sex, education level, and work experience), knowledge and behaviour of food handling related to food safety were obtained from the questionnaire. All the questions being closed and it was compiled based on previous research[12] and adapted for the context of research on school catering. Adjustments were made to ensure the questions were relevant in the context of internal catering services without formal certification.

Swab tests were performed on both hands of the food handlers, and samples were analysed in a microbiology laboratory using Endo agar and eosin methylene blue agar (EMBA) media to detect *E. coli*. After initial identification, samples suspected to be positive for *E. coli* were further confirmed with (Indole, Methyl red, Voges-Proskauer, Citrate) IMViC tests to confirm the presence of the bacteria. The independent variables were the knowledge level and behaviour of the food handlers. The dependent variable was the presence of *E. coli* bacteria.

Data analyses

The collected data were analysed using IBM SPSS statistical software version 20. A univariate analysis was performed to determine the demographic characteristics of food handlers. Frequency and percentage (%) were used as categorical variables. A bivariate analysis using the chi-square test was performed to identify the relationships between the independent and dependent variables. The presence of *E. coli* from the hand swab was identified with a positive/ negative value and a percentage of the total number of food handlers.

Ethical considerations

This study was approved by the Research Ethics Committee (number: 578/EA/KEPK-FKM/2023). The participants were provided with complete information about the research objectives and their rights as research participants. Participation in this study was voluntary, and all collected data were kept confidential.

RESULTS

The majority of the food handlers were older than 40 years (72.7%; 64 respondents), whereas 27.3% (24 respondents) were younger than 40 years. As many as 75% (66 respondents) of the food handlers were women and 25% (22 respondents) were men. A total of 25% (22 respondents) had a bachelor's degree, 46.6% (41 respondents) completed high school, 14.8% (13 respondents) completed junior high school, and 13.6% (12 respondents) graduated from elementary school.

The majority of food handlers had more than 4 years of work experience in food processing (59.1%; 52 respondents), whereas 40.9% (36 respondents) had less than 4 years of work experience. However, regarding experience in food safety training, 75% (66 respondents) had never participated in training and only 25% (22 respondents) had participated in training. The majority of food handlers (60.2%, 53 respondents) had inadequate food safety knowledge, including important aspects such as hand hygiene and cross-contamination prevention; only 39.8% (35 respondents) had good knowledge.

The behaviour of food handlers in applying food safety principles varied. Only 38.6% (34 respondents) demonstrated good behaviour; the majority (61.4%; 54 respondents) demonstrated inadequate behaviour in daily practice. These data indicate a gap between knowledge and application, suggesting many food handlers do not consistently implement food safety standards in their daily work.

The microbiological test results from 88 hand swab samples of the food handlers determined 16 samples had suspected *E. coli* (+) colonies because the colonies were a golden yellow colour on Endo agar medium and a metallic green colour on EMBA media.

The colonies suspected positive for *E. coli* were checked for grams, and 13 preparations showed the presence of gram-negative bacteria in the form of rods (*bacilli*) suspected of *E. coli* bacteria. *E. coli* was confirmed by conducting an IMViC test, which yielded 9 positive *E. coli* samples.

Thus, the results of microbiological tests from 88 samples from the food handler swabs showed that 9 samples were positive for *E. coli*, whereas the 79 other samples were negative for *E. coli*. The percentage of samples positive for *Escherichia coli* was 10.2%, whereas the percentage of samples negative of *E. coli* was 89.9% (Table 1).

The metallic green colony that grows on the EMBA medium can be assumed to be *E. coli* (Figure 1). The bacteria form metallic colonies due to the reaction between the bacteria and methylene blue dye. Colonies suspected of *E. coli* were confirmed using the (IMViC) test (Figure 2). The isolation and identification test results using the test conducted with the 88 hand swab samples determined 9 samples were positive for *E. coli*, whereas the other 79 samples were negative for *E. coli*. The percentage of *E. coli*-positive samples was 10.2% and the percentage of negative samples of *E. coli* was 89.9% (Table 2).

Table 1. Frequency distribution of the demographic data, knowledge levels, behaviour, and contamination of *Escherichia coli* bacteria from food handlers

Characteristic	Frequency	Percentage
1. Age		
<40 years	24	27.3%
>40 years	64	72.7%
Total	88	100%
2. Sex		
Males	22	25 %
Females	66	75%
Total	88	100%
3. Education		
Primary school	12	13.6%
Junior High School	13	14.8%
High School	41	46.6%
Bachelor's degree	22	25%
Total	88	100%
4. Long Term Employees		
<4 years	36	40.9%
>4 years	52	59.1%
Total	88	100%
5. Training Experience		
Never Trained	66	75%
Trained	22	25%
Total	88	100%
6. Knowledge of Food Handling		
Bad	53	60.2%
Good	35	39.8%
Total	88	100%
7. Handler Behaviour		
Good	34	38.6%
Bad	54	61.4%
Total	88	100%
8. *Escherichia coli* bacterial contamination		
Positive	9	10.2%
Negative	79	89.8%
Total	88	100%

The bivariate analysis showed no significant relationship between the level of knowledge level of the food handlers and the presence of *E. coli* on their hands (p = 0.135). Of the 9 food handlers with detected *E. coli*, the majority (8 handlers, 15.1%) had poor knowledge, whereas only 1 handler with good knowledge detected *E. coli* (2.9%).

Based on the knowledge levels (Table 1), of the 88 food handlers, 60.2% (53) had poor knowledge and 39.8% (35) had good knowledge. Thus, although the proportion of handlers with poor knowledge was higher overall, the number of handlers contaminated with *E. coli* in this group was also larger (15.1%) than that in the good knowledge group (2.9%). These findings indicated that handlers with poor knowledge tended to be more susceptible to *E. coli* contamination.

The bivariate analysis revealed a significant relationship between the food handlers'

Figure 1. Alleged *Escherichia coli* (+) colony in the Endo media

behaviour and the presence of *E. coli* on their hands (p = 0.031). Of the food handlers who tested positive for *E. coli*, all (100%) came from the groups with poor behaviour. In contrast, none of those in the good behaviour group tested positive for *E. coli*.

Regarding behaviour, 61.4% of the food handlers (54) exhibited bad behaviour, whereas 38.6% (34) exhibited good behaviour. These results suggest that food handlers with poor behaviour have a much higher risk of being contaminated with *E. coli* than those with better behaviour. This significant association indicated that good food safety practices can effectively reduce contamination risk.

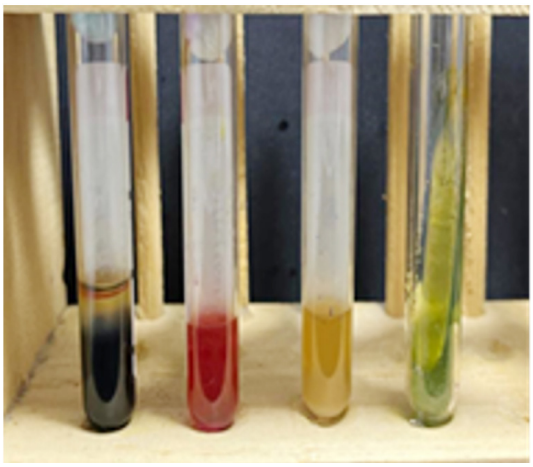

Figure 2. *Escherichia coli*-positive biochemical sequence test results from samples suspected to be *Escherichia coli* positive at the IMViC examination

DISCUSSION

Food safety in schools, especially practiced by catering services that provide lunches for students, is a very important issue, considering that students are vulnerable to foodborne diseases.[13] Food handlers prepare and serve food, which significantly affect food safety.[10,14] This study revealed an imbalance between knowledge and behaviour of food handlers in applying food safety principles, which can potentially increase the risk of *E. coli* bacteria contamination.

The majority of food handlers included in this study were women (75%), older than 40 years (72.7%) and had completed high school education (46.6%). These demographic factors are relevant to previous research results, which suggest women are often more involved in food management in school and household settings, although their knowledge is often limited to basic food safety practices.[15,16] Junior high or elementary school graduates, lower education levels, can be a factor that affects motivation to implement adequate food safety standards.[14,15] Previous findings also show that the higher the level of education in food handlers, the more likely they are to carry out hygienic food handling practices.[17]

The majority of food handlers had more than 4 years of work experience. However, 75% had never attended formal food safety training programmes. This reflected the gaps in knowledge and practice caused by a lack of ongoing training programs. Previous studies have

Table 2. Bivariate Analysis

Variable	*Escherichia coli* Contamination				Total		PR (95% CI)	P-value
	Positive		Negative		N	%		
	N	%	N	%	N	%		
Knowledge Level of Handlers								
Bad	8	15.1	45	84.9	52	100	-	P = 0.135
Good	1	2.9	34	97.1	35	100		
Total	9	10.2	79	89.8	88	100		
Handler Behaviour								
Bad	9	0	45	100	33	100	1.200CI	P = 0.031
Good	0	0	34	100	46	100	(1,065-1,352)	
Total	9	10.2	79	89.8	88	100		

*Chi-square test

shown that structured and routine training can improve knowledge and application of food safety practices.[16,18,19]

The study found that 39.8% of handlers had good food safety knowledge and 38.6% had good behaviour in daily practice. This gap indicates that good knowledge alone cannot ensure consistent application of food safety practices. The low proportion of well-behaved food handlers reinforces the finding that more than knowledge enhancement is needed, and more comprehensive interventions should include ongoing training and effective monitoring to ensure that knowledge is applied in real-life settings.[20]

Furthermore, the results of microbiology tests showed that 10.2% of the food handlers tested positive for *E. coli* on their hands. The existence of *E. coli* is closely associated with inadequate hand hygiene practices. This finding is quite concerning, considering that *E. coli* is a main indicator of faecal contamination that can cause foodborne diseases, especially among vulnerable students.[21] The presence of *E. coli* on the hands of food handlers has been linked to poor hygiene practices, indicating the need for more attention to personal hygiene training and supervision in school catering environments.[22,23]

This study showed a significant association between poor behaviour and *E. coli* contamination ($p = 0.031$). All contaminated handlers came from groups that displayed poor behaviour in food safety practices. These results align with those of other studies that state inadequate behaviour is a major risk factor for microbiological contamination.[24]

Nevertheless, no significant association was found between the knowledge of food handlers and the presence of *E. coli* on their hands ($p = 0.135$). Although most handlers with poor knowledge were at a risk of contamination, these results were not significant enough to confirm a strong relationship. These results are consistent with previous findings, suggesting that good knowledge of food safety can reduce contamination risk. However, although the knowledge of food handlers is important, the results of this study did not show a significant relationship. This may have been due to a lack of proper practice implementation, even though food handlers have sufficient knowledge, as revealed in a previous study.[9] These findings emphasize that in addition to increasing knowledge, behavioural change through training focused on good food safety practices is essential to reduce the risk of contamination.[6,15,25-27]

Overall, the findings of this study highlighted that increased knowledge alone was insufficient to ensure optimal food safety. The importance of continuous training and strict supervision to reduce food contamination risk in schools has become clear. In addition, school policymakers and administrators should prioritise certification and training of food handlers in internal school catering services to ensure student health and safety. Since students are a vulnerable group, these steps are crucial for reducing food contamination risk, which can be fatal. [28]

CONCLUSIONS

This study found that the behaviour of food handlers was significantly related to *E. coli* contamination. Although knowledge is important, these results indicate that the risk of contamination remains high without implementing good practices. The knowledge and behaviour of food handlers play an important role in preventing *E. coli* contamination in internal school catering services. Improving food safety in schools requires interventions that focus on improving the knowledge and behaviour of food handlers through comprehensive and sustainable training programs.

Ongoing training programs should be designed to address the gap between knowledge and behaviour. In addition, regular monitoring and evaluation should be implemented to ensure compliance with food safety standards. School policymakers and administrators must prioritise the certification and training of internal school catering staff to ensure student health and safety.

ACKNOWLEDGMENTS

The authors express their sincere gratitude to all respondents who participated and contributed to this study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

FUNDING

This study was funded by the Dissertation Research Grant (Dana Bantuan Penelitian Disertasi) under the Indonesian Education Scholarship (Beasiswa Pendidikan Indonesia/BPI), Ministry of Education, Indonesia, with Project Code FR202401000143.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

This study was approved by the Health Research Ethics Committee of the Faculty of Public Health, Diponegoro University, Indonesia (Approval No. 578/EA/KEPK-FKM/2023).

INFORMED CONSENT

Written informed consent was obtained from the participants before enrolling in the study.

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