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Microorganisms Causing Diarrhea in Food Served at Islamic Boarding Schools: A Descriptive Study in Surabaya, Indonesia

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Abstract: Diarrhea remains a major public health problem in Indonesia, particularly among children, and is often associated with the consumption of food contaminated by pathogenic microorganisms such as *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, and *Vibrio cholerae*. Islamic boarding schools represent communal living environments where shared food facilities and suboptimal hygiene practices may increase the risk of foodborne disease transmission. This study aimed to identify the presence of diarrheagenic microorganisms in food consumed by students at an Islamic boarding school in Surabaya, Indonesia, and to assess potential behavioral and environmental risk factors related to food safety. A descriptive observational study with a cross-sectional design was conducted. Food samples were purposively collected from three food stalls frequently visited by students. Microbiological examination was performed using selective media, including Eosin Methylene Blue Agar for *E. coli*, Salmonella Shigella Agar for *Salmonella* and *Shigella*, Mannitol Salt Agar for *Staphylococcus aureus*, and Thiosulfate Citrate Bile Salts Sucrose Agar for *Vibrio cholerae*. The results were analyzed descriptively and compared with national food safety standards issued by the Indonesian Ministry of Health and the National Agency of Drug and Food Control (BPOM). Laboratory analysis showed that none of the tested food samples were contaminated with the targeted diarrheagenic microorganisms. However, observational findings revealed several potential risk factors, including inadequate handwashing practices, improper food storage at room temperature, and poor personal hygiene among food handlers and students. In conclusion, although the sampled food met microbiological safety standards at the time of examination, persistent hygiene and sanitation issues indicate an ongoing risk for diarrheal disease. Continuous food safety education and improved sanitation practices are essential to prevent future outbreaks in Islamic boarding school settings.

Keywords: diarrhea, foodborne pathogens, Islamic boarding school, food hygiene, sanitation

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Introduction

Diarrheal disease remains a major public health concern worldwide and continues to contribute substantially to morbidity and mortality, particularly among children in low- and middle-income countries. The World Health Organization reported that diarrheal diseases are among the leading causes of illness and death in children under five years of age, with unsafe food and poor sanitation as key contributing factors (World Health Organization, 2022). In Indonesia, diarrhea remains a recurrent public health problem, especially in settings where hygiene and sanitation practices are inadequate.

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One of the primary causes of diarrhea is the consumption of food contaminated with pathogenic microorganisms, including *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, and *Vibrio cholerae* (Apriani et al., 2019). These pathogens are commonly associated with improper food handling, inadequate cooking, poor personal hygiene of food handlers, and unsafe food storage conditions. Food safety challenges are particularly pronounced in communal environments, where food is prepared and consumed collectively.

Islamic boarding schools (*pondok pesantren*) represent a unique communal living setting in Indonesia, where students live, study, and eat together on a daily basis. Such conditions may increase vulnerability to foodborne disease transmission due to shared facilities, high population density, and limited sanitation infrastructure. Several studies conducted in Indonesian Islamic boarding schools have demonstrated that suboptimal food hygiene and sanitation practices among food handlers significantly influence food safety outcomes (Amalia et al., 2020; Suyitno et al., 2024). These findings indicate that behavioral and environmental factors play a crucial role in determining food safety in boarding school settings.

In recent years, foodborne disease outbreaks in educational institutions have continued to be reported in Indonesia. Investigations in Gunungkidul and Bantul identified *Bacillus cereus* and *Salmonella* spp. as common causative agents of diarrhea, with improper food storage, inadequate reheating, and cross-contamination identified as major risk factors (Son et al., 2020; Iskandar et al., 2024). Although such outbreaks highlight the importance of microbiological surveillance, routine laboratory findings may not always detect pathogens at the time of sampling, particularly in the absence of an ongoing outbreak. Therefore, the assessment of behavioral and environmental risk factors remains essential for comprehensive food safety evaluation.

Despite the importance of food safety in Islamic boarding schools, microbiological surveillance data on food served in these settings remain limited, particularly in urban areas such as Surabaya. Most existing studies focus either on outbreak investigations or on food handler behavior, with fewer studies integrating microbiological examination and contextual risk factor assessment. Addressing this gap is important to provide baseline data that can inform preventive strategies.

Therefore, this study aimed to identify the presence of selected diarrheagenic microorganisms in food consumed by students at an Islamic boarding school in Surabaya, Indonesia, and to assess behavioral and environmental factors that may influence food contamination risk. The findings of this study are expected to contribute to food safety surveillance efforts and support the development of preventive interventions to reduce diarrheal disease risk in Islamic boarding school environments.

Materials and Methods

Study Design and Setting

This study employed a descriptive observational design with a cross-sectional approach. The research was conducted at an Islamic boarding school located in Surabaya, Indonesia. The boarding school represents a communal living environment where students reside and consume food prepared or sold within or around the school area.

Food Sample Collection

Food samples were collected using purposive sampling from three food stalls most frequently visited by students of the Islamic boarding school. The selected stalls represented the primary sources of daily food consumption for the students. A total of three food samples were collected, each representing ready-to-eat food items available at the time of sampling. Samples were aseptically collected using sterile containers and immediately transported to the microbiology laboratory for analysis to minimize the risk of external contamination.

Microbiological Examination

Microbiological analysis was conducted to detect the presence of selected diarrheagenic microorganisms. Each food sample was cultured using selective media according to standard microbiological procedures. Eosin Methylene Blue Agar (EMBA) was used for the detection of *Escherichia coli*. Salmonella Shigella Agar (SSA) was used to identify *Salmonella* spp. and *Shigella* spp. Mannitol Salt Agar (MSA) was used for the isolation of *Staphylococcus aureus*, while Thiosulfate Citrate Bile Salts Sucrose Agar (TCBS) was used to detect *Vibrio cholerae*. Plates were incubated at 37°C for 24–48 hours, and bacterial growth was identified based on colony morphology characteristics in accordance with standard laboratory guidelines.

Behavioral and Environmental Observation

In addition to laboratory examination, observational assessments were conducted to identify potential behavioral and environmental risk factors related to food safety. Observations focused on handwashing practices, food storage conditions, food handling behavior, and personal hygiene of food handlers and students. These observations were recorded descriptively without the use of structured behavioral scoring instruments.

Data Analysis

Data were analyzed descriptively. Laboratory findings were presented as the presence or absence of the targeted microorganisms and compared with microbiological safety standards established by the National Agency of Drug and Food Control (BPOM, 2018) and the Indonesian Ministry of Health (Kemenkes, 2021). Observational findings were summarized to provide contextual interpretation of potential food safety risks within the boarding school environment.

Ethical Considerations

This study did not involve human or animal subjects and did not collect personal or identifiable participant data. The research focused solely on food samples and general environmental observations. Therefore, formal ethical clearance was not required. Permission to conduct the study was obtained from the management of the Islamic boarding school prior to data collection.

Result and Discussion

Microbiological Examination Results

Microbiological analysis was performed on three ready-to-eat food samples obtained from food stalls frequently visited by students of the Islamic boarding school. The examination targeted five common diarrheagenic microorganisms, namely *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, and *Vibrio cholerae*, using selective culture media.

The laboratory results showed that none of the food samples were contaminated with the tested microorganisms. No characteristic colony growth of *E. coli* was observed on Eosin Methylene Blue Agar. Similarly, no growth suggestive of *Salmonella* spp. or *Shigella* spp. was detected on Salmonella Shigella Agar. Examination on Mannitol Salt Agar revealed no colonies consistent with *Staphylococcus aureus*, and no suspected *Vibrio cholerae* colonies were observed on Thiosulfate Citrate Bile Salts Sucrose Agar.

All microbiological findings complied with the national food safety standards, which require the absence of these pathogenic microorganisms in ready-to-eat food products, as stipulated by the National Agency of Drug and Food Control (BPOM, 2018) and the Indonesian Ministry of Health (Kemenkes, 2021).

Table 1. Laboratory Results of Food Sample Testing

Microorganism Tested	Selective Media Used	Laboratory Result (n = 3 samples)	Standard Reference (BPOM 2018; Kemenkes 2021)
Escherichia coli	EMBA	Not detected	Absence in food samples
Salmonella spp.	SSA	Not detected	Absence in food samples
Shigella spp.	SSA	Not detected	Absence in food samples
Staphylococcus aureus	MSA	Not detected	Absence in food samples
Vibrio cholerae	TCBS	Not detected	Absence in food samples

Discussion

This study demonstrated that none of the tested food samples collected from food stalls around an Islamic boarding school in Surabaya were contaminated with the five targeted diarrheagenic microorganisms, namely *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, and *Vibrio cholerae*. These findings indicate that, at the time of sampling, the examined food items met the microbiological safety standards established by the National Agency of Drug and Food Control (BPOM, 2018) and the Indonesian Ministry of Health (Kemenkes, 2021).

Although no pathogenic microorganisms were detected, the absence of laboratory-confirmed contamination should not be interpreted as the absence of foodborne disease risk. Food safety is a multifactorial issue influenced not only by microbial presence but also by food handling practices, environmental sanitation, and human behavior. Similar conclusions have been reported in previous studies, which emphasized that

safe laboratory findings do not necessarily reflect long-term food safety, particularly in communal living environments (Suyitno et al., 2024).

The findings of this study are consistent with research conducted in Indonesian Islamic boarding schools, where food safety outcomes were closely related to the behavior of food handlers and students rather than laboratory results alone (Amalia et al., 2020). In contrast, outbreak investigations conducted in other educational settings in Indonesia have reported the presence of *Bacillus cereus* and *Salmonella* spp. as causative agents of diarrheal outbreaks (Son et al., 2020; Iskandar et al., 2024). These differences may be explained by variations in timing, food storage conditions, and the occurrence of specific risk behaviors that facilitate bacterial growth, such as prolonged storage at room temperature and inadequate reheating.

Observational findings in the present study revealed several behavioral and environmental risk factors that may contribute to diarrheal disease transmission, including inadequate handwashing practices, improper food storage, and poor personal hygiene among food handlers and students. Hand hygiene has been widely recognized as one of the most effective measures to reduce the incidence of diarrheal diseases (Wulandari & Dewi, 2019; Lestari et al., 2021). However, compliance with proper handwashing practices remains a challenge in communal boarding school environments, where shared facilities and collective norms may limit individual adherence.

Bloom's health behavior theory provides a useful framework for interpreting these findings. The theory suggests that health behaviors are shaped by knowledge, attitudes, and environmental influences (Bloom, 1974). In the context of Islamic boarding schools, collective routines and social norms strongly influence individual hygiene practices. Therefore, improving food safety requires not only microbiological monitoring but also sustained behavioral interventions that target both food handlers and students.

From a public health perspective, the findings highlight the importance of routine food safety surveillance in Islamic boarding schools, even in the absence of documented outbreaks. Baseline microbiological data, combined with contextual assessment of behavioral and environmental factors, can serve as an early preventive measure to reduce the risk of future diarrheal disease outbreaks. Similar approaches have been recommended in other low-resource and communal settings, where preventive strategies are often more effective than outbreak response alone (World Health Organization, 2022).

Limitations

This study has several limitations that should be acknowledged. First, the microbiological examination was limited to five diarrheagenic microorganisms, and other potential pathogens, such as *Bacillus cereus* or *Clostridium perfringens*, were not included. Second, the number of food samples was small and collected from only three food stalls, which may limit the generalizability of the findings. Third, behavioral and environmental observations were descriptive in nature and did not utilize standardized quantitative assessment tools.

Implications for Future Research

Future studies should involve a larger number of food samples and include a broader range of foodborne pathogens. The use of molecular diagnostic methods, such as polymerase chain reaction (PCR), may improve the sensitivity of pathogen detection. Longitudinal or seasonal studies would also be valuable to capture variations in contamination risk over time. Additionally, interventional research assessing the effectiveness of structured food safety education and hygiene promotion programs in Islamic boarding schools is warranted.

Conclusion

This study found that food samples collected from food stalls frequently visited by students at an Islamic boarding school in Surabaya were free from the selected diarrheagenic microorganisms, including *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, and *Vibrio cholerae*, and met national microbiological safety standards. However, the presence of suboptimal food handling practices, inadequate hand hygiene, and improper food storage conditions indicates that the risk of diarrheal disease remains.

These findings highlight that microbiological safety at a single point in time does not fully reflect long-term food safety in communal living environments. Therefore, preventive strategies should not rely solely on laboratory testing but must also address behavioral and environmental determinants of food safety. Regular food safety monitoring, structured hygiene education for food handlers and students, and improvements in sanitation facilities are essential to reduce the risk of

future foodborne disease outbreaks in Islamic boarding schools.

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