

Association of Hygiene and Sanitation Practices with *Staphylococcus aureus* and *Escherichia coli* Contamination In Poultry Slaughterhouses of DKI Jakarta

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ABSTRACT

Background: Poultry meat is a major source of animal protein in Indonesia; however, inadequate hygiene and sanitation during slaughtering and processing increase the risk of bacterial contamination in poultry slaughterhouses.

Aims: This study examined the association between workers' hygiene and sanitation practices and *Staphylococcus aureus* contamination, differences in *Escherichia coli* contamination among government-managed poultry slaughterhouses in DKI Jakarta, and their implications for poultry meat safety management.

Methods: A cross-sectional study was conducted from May to December 2025 in six government-managed poultry slaughterhouses in DKI Jakarta Province. Hygiene and sanitation practices were assessed among 90 workers using structured questionnaires and direct observations. Microbiological analyses were performed on workers' hand swabs for *S. aureus* (n = 90) and chicken meat samples for *E. coli* (n = 30). Statistical analyses were conducted to evaluate associations between hygiene practices and bacterial contamination levels.

Results: Workers' hygiene practices were significantly associated with *S. aureus* contamination on workers' hands ($p < 0.05$). In contrast, *E. coli* contamination primarily reflected facility-level sanitation rather than individual worker behaviour. All slaughterhouses exceeded the maximum permissible *E. coli* limit established by SNI 3924:2009. Variations in contamination levels were associated with infrastructure conditions, production volume, workflow organization, equipment sanitation, and separation between clean and dirty areas. Although workers' knowledge and attitudes influenced hygiene practices, implementation remained inconsistent.

Conclusion: High bacterial contamination levels indicate inadequate compliance with hygiene and sanitation standards in poultry slaughterhouses. Strengthening worker training, supervision, and sanitation management is essential to reduce cross-contamination and improve poultry meat safety.

INTRODUCTION

Poultry meat is a major source of animal protein in Indonesia, with per capita consumption increasing from 12.58 kg/year in 2023 to 13.60 kg/year in 2025 (Rahayu, 2024; Ditjen PKH Kementan, 2025). This increase

highlights the need to ensure poultry meat safety in line with ASUH principles (safe, healthy, wholesome, and halal) (Wijiniyah, 2020). Inadequate hygiene and sanitation during slaughtering and processing can increase the risk of bacterial contamination as production volumes grow.

Poultry slaughterhouses (RPHUs) are critical points for cross-contamination through workers' hands, equipment, and processing surfaces. *Staphylococcus aureus*, a common skin bacterium, is widely used as an indicator of personal hygiene and is associated with poor hand hygiene, improper use of personal protective equipment, and skin lesions among workers. Hygiene compliance is also influenced by demographic factors such as age, education, work experience, and hygiene and sanitation training (Sidabalok et al., 2019; Komalasari et al., 2022; Sabela et al., 2024).

In contrast, *Escherichia coli* contamination primarily reflects sanitation effectiveness at the facility level, being linked to inadequate cleaning and disinfection, poor separation between clean and dirty areas, contaminated water sources, and high pro-cessing intensity (Sipayung et al., 2023). Although the Provincial Government of DKI Jakarta manages six RPHUs, evidence linking workers' hygiene practices to *S. aureus* contamination and explaining differences in *E. coli* contamination among RPHUs re-mains limited. Therefore, this study aimed to analyze the association between workers' hygiene practices and *S. aureus* contamination in relation to demo-graphic characteristics, and to assess differences in *E. coli* contamination among RPHUs.

MATERIALS AND METHODS

Ethical Approval

This study involved human participants and did not include invasive procedures or animal experimentation. Ethical clearance was obtained from the Ethics Committee for Research Involving Human Subjects, IPB University (Approval No. 1925/IT3.KEPMSM-IPB/SK/2025). Participation was voluntary, and writ-ten informed consent was obtained from all respondents prior to data collection.

Research Period and Location

The research was conducted from May 2025 to February 2026 at six poultry slaughterhouses in Jakarta, namely Rawa Kepiting, Petukangan Utara, Lokbin Pasar Minggu, Rawa Lele, Rorotan, and Rawa Terate. Microbiological analyses were performed at the Animal Product Quality Testing and Certification Center (Balai Pengujian Mutu dan Sertifikasi Produk Hewan/BPMSPH), Bogor.

Experimental design

A cross-sectional study was conducted to evaluate hygiene and sanitation practices among poultry slaughterhouse workers and their association with bacterial contamination. The study population comprised workers assigned to clean processing areas who had direct contact with chicken meat during slaughtering and carcass handling. A total of 90 workers were selected using proportionate simple random sampling from each poultry slaughterhouse (RPHU), and the distribution of respondents is presented in Table 1. Chicken meat samples were collected using stratified equal allocation sampling, with five samples obtained from each RPHU. Data were collected on the same day through structured questionnaires, unannounced direct observations, and microbiological sampling.

Assessment of Hygiene and Sanitation Practice Instruments and Bacterial Contamination Levels

Hygiene and sanitation practices were assessed using a structured questionnaire consisting of 10 questions and direct observations comprising 11 statements, developed based on the Indonesian Ministry of Agriculture Regulation No. 15 of 2021 concerning Business Activity Standards and Product Standards for Risk-Based Business Licensing in the Agricultural Sector. The questionnaire was pilot tested on 30 respondents

Table 1. Proportional allocation of respondents across poultry slaughterhouses

No.	RPHU*	Population (people)	Proportion	Sample Size (people)
1.	Rawa Kepiting	625	$625 / 1.220 \times 90$	46
2.	Petukangan Utara	83	$83 / 1.220 \times 90$	6
3.	Lokbin Pasar Minggu	15	$15 / 1.220 \times 90$	1
4.	Rawa Lele	123	$123 / 1.220 \times 90$	9
5.	Rorotan	76	$76 / 1.220 \times 90$	6
6.	Rawa Terate	298	$298 / 1.220 \times 90$	22
Total		1.220		90

*RPHU: Rumah Potong Hewan Unggas (poultry slaughterhouse)

outside the study sample, and instrument validity and reliability were evaluated using Pearson Product Moment and Cronbach's alpha tests, respectively (Zulfikar et al., 2024).

Questionnaires captured self-reported practices, while observations assessed the actual implementation of personal hygiene, equipment and environmental sanitation, separation of clean and dirty areas, and facility management at poultry slaughterhouses. Combining questionnaire and observational methods aimed to improve the objectivity and validity of behavioral measurements (van Dijk et al., 2023). Practice scores were weighted at 30% for questionnaire data and 70% for observational data, using a three-point scale: "always" (2), "sometimes" (1), and "never" (0), and categorized as poor (<12), moderate (12–23), or good (>23). Microbiological analyses of *S. aureus* on workers' hand swabs and *E. coli* on chicken meat samples were conducted at BPMSPH using SNI ISO 6888-1:2012 and The Oxoid Manual 9th edition, respectively.

Data Analysis

Hygiene and sanitation practice data were analyzed descriptively to summarize workers' practice levels at RPHU. *Staphylococcus aureus* contamination levels on workers' hand swabs were also analyzed descriptively as an indicator of personal hygiene conditions, while the association between hygiene and sanitation practices and *S. aureus* contamination levels was assessed using Spearman's correlation test in SPSS version 24 (Nadhira et al., 2024). Differences in *Escherichia coli* contamination levels among RPHUs were evaluated using one-way ANOVA, followed by Duncan's Multiple Range Test when significant differences were detected. Duncan's test was applied to identify homogeneous groups among RPHUs and to facilitate comparison between sanitation practice patterns and contamination levels (Agbangba et al., 2024).

RESULTS AND DISCUSSION

Demographic Characteristics

Based on the descriptive analysis of 90 poultry slaughterhouse workers in DKI Jakarta, most respondents were in the productive age group of 30–39 years (38,9%), with a mean age score of $2,76 \pm 0,93$. The majority had completed junior or senior high school education (72,2%), and none had attained tertiary education. Most workers had 1–5 years of work experience (44,4%), followed by 6 to 10 years (31,1%). Nearly all respondents (96,7%) reported no history of

communicable diseases, while participation in formal hygiene and sanitation training was limited, with only 31,1% having attended such training.

Across slaughterhouses, demographic characteristics showed some variation. Workers in Lokbin Pasar Minggu and Rawa Kepiting were predominantly aged 30–39 years, whereas those in Petukangan Utara, Rawa Lele, and Rorotan were mainly aged 20–29 years. Rawa Terate was also dominated by workers aged 30–39 years. Secondary education and moderate work experience of 1–5 years were common across all RPHUs. Most workers in all slaughterhouses reported no history of communicable diseases, and the majority had never participated in formal hygiene and sanitation training.

Hygiene and Sanitation Practices

Descriptive analysis showed that the overall mean hygiene and sanitation practice score among poultry slaughterhouse workers in DKI Jakarta was $17,26 \pm 1,73$, which was classified as moderate. However, observational findings indicated that a moderate score did not necessarily reflect consistently safe practices during slaughtering and processing, revealing a discrepancy between practice scores and actual behaviour.

Although workers generally demonstrated basic awareness of hygiene principles, direct observations identified frequent deviations from standard procedures. These included eating and smoking during processing, cutting carcasses on the floor, inconsistent use of personal protective equipment, and handling carcasses with open wounds or skin conditions on the hands. Handwashing facilities were generally available but were not consistently or properly used. In addition, several RPHUs showed inadequate separation between clean and dirty areas, unrestricted movement of workers between processing zones, and suboptimal supporting facilities such as non-functional handwashing stations, absence of soap, dirty surfaces, and poorly maintained toilets. Key observational findings are presented in Figures 1 and 2.

By slaughterhouse, hygiene and sanitation practices varied. Petukangan Utara recorded the highest mean score ($21,20 \pm 1,13$) with relatively better compliance, followed by Rawa Kepiting ($18,01 \pm 0,75$). In contrast, Lokbin Pasar Minggu, Rawa Lele, Rawa Terate, and Rorotan exhibited moderate practices characterized by repeated procedural deviations. Mean practice scores by RPHU are presented in Table 2. These deviations provide a plausible explanation for the observed *S. aureus* contamination on workers' hands and support

further analysis of the association between hygiene practices and bacterial contamination.

***Staphylococcus aureus* Contamination on Workers' Hands**

Microbiological analysis of hand swabs from 90 workers detected *S. aureus* contamination across all six poultry slaughterhouses (RPHUs), with a mean level of $2.40 \pm 0.91 \log_{10}$ CFU/cm² (geometric mean 251.2 CFU/cm²). This indicates that workers' hands may serve as a source of bacterial contamination during poultry processing. Contamination levels varied among RPHUs, suggesting differences in hygiene conditions and practice consistency.

Spearman's correlation showed a significant but weak positive association between hygiene and sanitation practice scores and *S. aureus* contamination on workers' hands ($\rho = 0.232$; $p = 0.028$), indicating that poorer practices were associated with higher contamination, although other factors may also contribute.

***Escherichia coli* Contamination on Chicken Meat**

Analysis of chicken meat samples ($n = 30$) showed that *E. coli* contamination was detected in all RPHUs, with an overall mean level of $2.72 \pm 0.74 \log_{10}$ CFU/cm² (approximately 524.8 CFU/cm²). These levels

exceeded the maximum permissible limit for fresh chicken meat established by the Indonesian National Standard (SNI 3924:2009), which is $1 \log_{10}$ CFU/g, indicating inadequate sanitation control across all facilities.

Descriptive analysis revealed variability in *E. coli* contamination levels among RPHUs, suggesting differences in sanitation effectiveness and operational conditions. One-way ANOVA demonstrated a significant difference in *E. coli* contamination among RPHUs ($F = 13.651$; $p < 0.001$). Duncan's multiple range test further grouped the RPHUs into two homogeneous subsets, with Lokbin Pasar Minggu and Rorotan showing significantly lower contamination levels compared to the other RPHUs. The results of the post hoc analysis are presented in Table 3.

This research demonstrated that hygiene and sanitation practices among poultry slaughterhouse workers were significantly associated with *S. aureus* contamination on workers' hands, whereas *E. coli* contamination on chicken meat differed significantly among RPHUs. These findings indicate that personal hygiene behaviour and facility-level sanitation contribute differently to bacterial contamination patterns in poultry slaughterhouses, consistent with previous studies conducted in poultry processing environments (Komalasari et al., 2022). Although

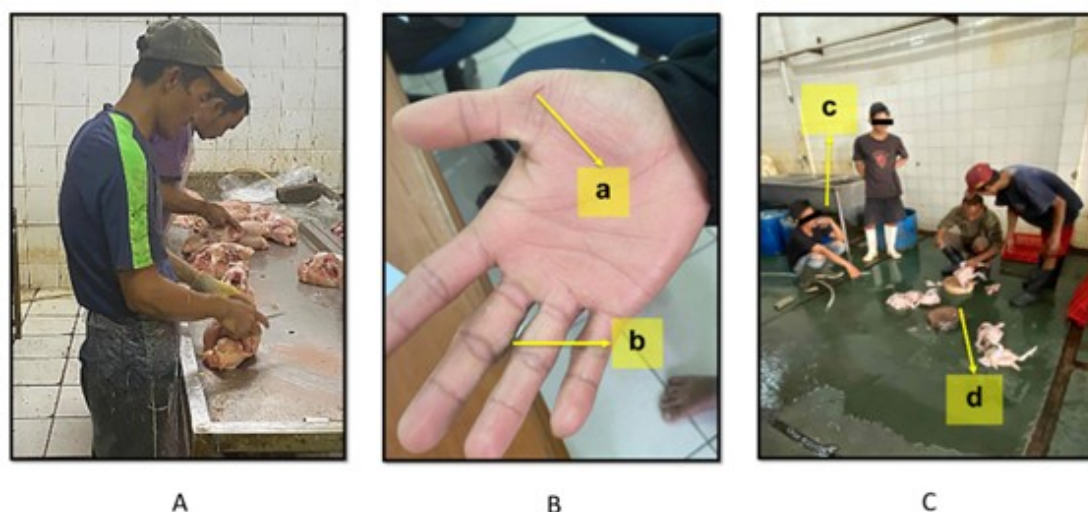


Figure 1. Observed hygiene practice deficiencies among workers in poultry slaughterhouses (RPHUs) in Jakarta, Indonesia. (A) Incomplete use of personal protective equipment (PPE) by workers across all surveyed slaughterhouses. (B) Presence of an open wound (a) and a wart (b) on workers' palms. (C) Chicken slaughtering performed while smoking (c) and directly on the floor (d).

hygiene and sanitation practices were predominantly classified as moderate based on composite practice scores, direct observations revealed substantial deviations from standard operating procedures during slaughtering and carcass handling. This discrepancy suggests that questionnaire-based assessments may overestimate actual compliance, particularly when practice measurements partly rely on self-reported data. In line with this finding, da Cunha et al. (2019) reported that hygiene practices documented through questionnaires often do not reflect actual practices in the workplace, while Rayson et al. (2021) showed that self-reported hand hygiene compliance is generally higher than behaviour observed directly.

Several non-compliant behaviours observed in this study, including eating and smoking during processing, handling carcasses directly on the floor, inconsistent use of personal protective equipment, and handling meat with open wounds or skin lesions on the hands, may increase the risk of hand-borne contamination. These findings highlight the important role of workers' hands as a source of *S. aureus* contamination, as the bacterium is commonly present on human skin and hands and is widely recognized as an indicator of personal hygiene. Contamination of workers' hands with *S. aureus* represents a major food safety concern because the bacterium can produce heat-stable staphylococcal enterotoxins when bacterial



Figure 2. Non-compliance with sanitation practices and deficiencies in sanitation facilities observed in poultry slaughterhouses (RPHUs) in Jakarta, Indonesia. (A) Chicken slaughtering activities conducted in the clean area, with workers not wearing appropriate protective clothing (a), personal belongings hung on walls (b), and unrestricted movement of workers between clean and dirty areas (c). (B) Inadequate separation between clean and dirty areas. (C) Packaging of chicken meat performed in the dirty area. (D) Damaged and cracked walls and floors. (E) Non-functional handwashing facilities. (F) Unsanitary toilet conditions. (G) Non-functional changing room facilities. (H) Accumulation of dirt on the ceiling (a) and walls (b). (I) Walls made of non-waterproof materials (c). (J) Corroded feather-plucking equipment.

populations reach approximately 10^5 CFU/g (Gajewska et al., 2023). These toxins may remain hazardous even after bacteria are inactivated during processing or cooking, indicating that inadequate hygiene during handling can compromise poultry meat safety beyond the point of initial contamination.

The weak positive association between hygiene and sanitation practice scores and *S. aureus* contamination levels may reflect limitations in hygiene practice measurement rather than an actual increase in contamination risk associated with better practices. Questionnaire-based assessments are subjective and prone to over-reporting because workers may report desirable hygiene behaviours that are not consistently implemented in practice. In addition, collective questionnaire completion and similarities in respondents' answers may have reduced score variability and weakened the statistical relationship. Although direct observations were conducted, some workers appeared to perform hygiene procedures superficially or inconsistently, indicating that observed compliance did not necessarily reflect effective hygiene implementation. These findings suggest that the effectiveness of hygiene practices in reducing *S. aureus*

contamination depends not only on whether hygiene measures are performed, but also on their consistency, correctness, and supporting sanitation conditions in the workplace. Similar findings were reported by Guergueb et al. (2014) and Klaharn et al. (2022), who emphasized that proper and consistent hygiene implementation under adequate sanitation conditions is essential for reducing *S. aureus* contamination.

Worker demographic characteristics may also influence the implementation of hygiene and sanitation practices. In this study, most workers were of productive age and had moderate work experience; however, participation in formal hygiene and sanitation training was limited. Previous studies have shown that education level, work experience, and training exposure influence workers' consistency in applying hygienic practices, particularly in high-intensity processing environments. Insufficient training and supervision may therefore contribute to persistent non-compliance despite adequate work experience (Kimindu et al., 2024; Teferi, 2022). In addition, operational conditions such as production capacity, facility layout, and the effectiveness of sanitation system implementation may also influence *S. aureus*

Table 2. Mean Hygiene–Sanitation Practice Scores by RPHU

No.	RPHU	Sample Size (n)	Mean $\pm$ SD	Category
1.	Lokbin Pasar Minggu	1	33,40 $\pm$ –*	Moderate
2.	Petukangan Utara	6	42,90 $\pm$ 1,13	Good
3.	Rawa Kepiting	46	40,41 $\pm$ 0,75	Good
4.	Rawa Lele	9	32,90 $\pm$ 0,56	Moderate
5.	Rawa Terate	22	33,25 $\pm$ 0,84	Moderate
6.	Rorotan	6	32,65 $\pm$ 0,90	
Total		90	37,48 $\pm$ 3,91	Moderate

*SD was not calculated for RPHUs with a single respondent.

Table 3. Mean *Escherichia coli* contamination levels by RPHU based on Duncan's Multiple Range Test

No.	RPHU	<i>E. coli</i> Contamination Level
1.	Lokbin Pasar Minggu	1,75 $\pm$ 0,61 ^a
2.	Rorotan	2 $\pm$ 0,27 ^a
3.	Rawa Lele	3,49 $\pm$ 0,56 ^b
4.	Rawa Terate	3,09 $\pm$ 0,36 ^b
5.	Rawa Kepiting	2,95 $\pm$ 0,30 ^b
6.	Petukangan Utara	3,04 $\pm$ 0,25 ^b

^{a,b}Different superscripts in the same column showed significant differences ($p < 0.05$).

contamination levels and contribute to variability among RPHUs (Afrila et al., 2023).

In contrast to *S. aureus*, *E. coli* contamination on chicken meat primarily reflects sanitation effectiveness at the facility level rather than individual worker behaviour. All RPHUs included in this study exhibited *E. coli* contamination levels exceeding the maximum permissible limit established by SNI 3924:2009, indicating systemic sanitation deficiencies and potential food safety risks. Similar findings have been associated with inadequate cleaning and disinfection procedures, ineffective separation between clean and dirty areas, contaminated water sources, and high production intensity in poultry slaughterhouses (Susilaningrum et al., 2022; Sipayung et al., 2023). Significant differences in *E. coli* contamination among RPHUs further suggest that facility conditions, production volume, workflow organization, and sanitation management substantially influence contamination outcomes. Importantly, lower *E. coli* contamination levels were not consistently associated with higher hygiene and sanitation practice scores, indicating that fecal contamination is more strongly influenced by environmental and operational factors than by personal hygiene alone (Mpundu et al., 2019; Klaharn et al., 2022).

The consistently high *E. coli* contamination levels observed across all RPHUs also raise important public health concerns because contaminated poultry meat may facilitate the transmission of foodborne pathogens throughout the food distribution chain if not adequately controlled. Afrila et al., (2023) reported that inadequate implementation of Good Manufacturing Practices (GMP) and Sanitation Standard Operating Procedures (SSOP), particularly in sanitation and personal hygiene aspects, may increase the risk of microbial contamination in poultry slaughterhouses and compromise consumer food safety. Therefore, consistent implementation of sanitation control measures, routine monitoring, and stricter supervision are essential to reduce microbial contamination and improve poultry meat safety.

CONCLUSION

This study demonstrated that workers' knowledge and attitudes significantly influenced hygiene and sanitation practices, although implementation remained inconsistent. Older age negatively affected practice compliance. High *Staphylococcus aureus* and *Escherichia coli* contamination levels indicate persistent cross-contamination risks, underscoring the need for

consistent behaviour, improved facilities, regular training, and strengthened supervision.

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AUTHORS CONTRIBUTION

V.K.W. conceived and designed the study, developed the methodology, conducted data collection, performed formal analysis, curated the data, and drafted and revised the manuscript. E.S. and T.P. contributed to conceptualization, provided methodological guidance, supervised the research, critically reviewed the manuscript, assisted in data interpretation, and improved the scientific quality of the manuscript. D.H.W.H. contributed to microbiological analysis, including the identification of *S. aureus* and *E. coli* and bacterial colony enumeration. All authors read and approved the final version of the manuscript.

"The author declares that there is no conflict of interest with the parties involved in this research".

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