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Risk Factors for Avian Influenza Virus Subtype H9 Contamination in Live Bird Markets in Jakarta, Tangerang, and Bekasi, Indonesia

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Abstract

Low Pathogenicity Avian Influenza virus subtype H9N2 causes a decrease in egg production and two of the four defined H9N2 poultry lineages (G1 and Y280) have been associated with human infections. The high number of positive test results for the H9 virus in the live bird markets (LBMs) of the Greater Jakarta area in 2021 could be a source of transmission for the surrounding area. This study aims to determine the prevalence and risk factors that play a role in H9 virus contamination in the LBMs to establish a multivariate analysis model. A cross-sectional study was conducted on 87 vendors' stalls, and 124 broiler chickens from 44 LBMs randomly selected in Tangerang City, North Jakarta, and Bekasi City. Samples were collected as equipment swabs from the stalls of poultry carcass vendors, tracheal swabs, and cloacal swabs from broiler chickens. The test used was Real-Time Reverse Transcription Polymerase Chain Reaction. Data analysis was performed using univariate, bivariate, and multivariate analysis with logistic regression. The prevalence of H9 virus contamination at the LBM level in Greater Jakarta in 2022 was 77.27% (93% CI, α 7%), while the prevalence at the vendors' stall level was 51.72% (95% CI, α 5%). The risk factors for H9N2 virus contamination with a significant p-value < 0.05 include positive results in equipment swab samples, both equipment and broiler swabs, and the use of carcass sinks. The logistic regression model of H9 virus contamination at the vendors' stall level was Logit P (H9=1 | x) = 0.29924 + 1.58691 CARCASS_SINK - 2.42176 PPE. The risk factor contributing to the increase in H9 virus contamination is the use of carcass sinks, while personal protective equipment (PPE) such as aprons and boots reduces H9 virus contamination.

Keywords: H9; live bird market; prevalence; risk factor

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Introduction

Low Pathogenicity Avian Influenza (LPAI) virus subtype H9N2 causes losses for farmers due to its impact on egg production. H9N2 viruses have the potential to continue adapting, becoming more pathogenic in chickens and even more transmissible to humans, despite causing milder clinical symptoms than the Highly Pathogenic Avian Influenza Virus (HPAIV). Reassortment between Genotype 57 (G57 or genotype S) of H9N2 viruses and other circulating subtypes has led to several zoonotic AI viruses with a strong ability to induce disease and mortality in humans and poultry. Examples include H7N9 (1), H10N8 (2), and H5N6, all of which carry six genes from the internal G57 gene cassette (3). The initial recorded human cases, two children in Hong Kong in 1999, presented flu-like symptoms. Subsequent human infections have been reported in Egypt, Bangladesh, Pakistan, and Oman. Generally, H9N2 infections in humans are mild, with only one death reported from the virus, potentially linked to underlying health conditions. In addition to infecting birds and humans, this virus has also been found in pigs, minks, dogs, horses, ferrets,

bats, and rodents from the Lagomorpha order (4).

The increase in outbreaks in recent years across various parts of the world has led to speculation that H9N2 viruses could potentially cause more significant economic losses to the poultry production sector than outbreaks of the highly pathogenic, yet more localized, ones caused by H5 or H7 viruses. Prevalence studies of H9N2 viruses consistently yield high results, especially within live bird markets (LBMs). Live bird markets, serving as hubs of human and poultry activity, constitute a significant component of disease transmission pathways and have been shown to perpetuate the spread of AI virus infections among poultry while also facilitating zoonotic infections (5). The prevalence of H9N2 viruses has been found to exceed 3.5% in LBMs in Vietnam (6). Several studies conducted in live poultry and livestock markets in Bangladesh and Pakistan have demonstrated a prevalence of H9N2 viruses to be nearly 10% (7).

The live bird market is a significant source of AI virus transmission, admixture, and reassortment. Reassortment can occur for both high and low pathogenic viruses (8). A new H5N6 reassortant virus, containing an internal gene set like H9N2, with high and low pathogenic AIV subtypes, was identified circulating in domestic and wild birds (9). Additionally, live bird markets can be an essential source of new AI viruses (10). Environmental contamination and the infection of poultry in LBMs by H5N1 viruses were also reported in Indonesia (11). Live bird markets have been suspected as a primary source of human infections with AI viruses. Many patients with diseases due to H5N1 and H7N9 infections are believed to have contracted the viruses through indirect exposure to infected birds or via aerosols generated by the slaughter of poultry in markets (12).

H9N2 viruses were discovered in Indonesia in 2016, affecting chickens. Jonas et al. (13) conducted research mapping H9N2 infection cases and demonstrated that the virus had spread to Java, Sumatra, Kalimantan, Sulawesi, and Bali. Infections with these viruses led to the death of 1000 ducks in Bantul Regency, Yogyakarta, in 2016 (14). The disease also causes respiratory problems in poultry, resulting in a 50-78% decrease in egg production and up to 2.7% mortality in laying hens in the Sidrap District, South Sulawesi (15).

Avian influenza (AI) surveillance by the Disease Investigation Center of Subang has been ongoing since 2019, encompassing the profiling of 90 LBMs within the Greater Jakarta area. The results of AI virus subtype identification in 2021 indicated that all samples tested were H9 viruses, leading this research to focus exclusively on identifying H9 viruses. Research locations were selected based on three districts with the highest incidence rates (ranging from 66.7% to 100%). The primary objective of this study is to determine the prevalence and risk factors contributing to H9 contamination in the LBMs of Jakarta, Tangerang, and Bekasi, to develop a multivariate analysis model.

Materials and Methods

Ethical approval and informed consent

The ethical clearance certificate (0108/EC-FKH/Eks./2022, dated Nov 22, 2022) was obtained from the Animal Ethics Committee of the Faculty of Veterinary Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia. Informed consent was obtained from all respondents prior to the study.

Study period and location

The research was conducted from October 2022 to January 2023. Sampling was performed in Bekasi City, North Jakarta, and Tangerang City. The Biotechnology Laboratory of the Disease Investigation Center of Subang undertook the identification of the H9 virus. The design and data analysis were conducted at the Veterinary Public Health Laboratory, Faculty of Veterinary Medicine, Universitas Gadjah Mada.

Study framework

A cross-sectional study was conducted on randomly selected LBMs in Tangerang City, North Jakarta, and Bekasi City. The sampling technique used was proportional random sampling, whereby the number of markets and vendors' stalls were calculated proportionally. The selection of markets, vendors' stalls, and broiler chickens was performed using a simple random sampling technique. Market data were acquired from local government sources for Tangerang City, North Jakarta, and Bekasi City, resulting in 89 markets across the three regions. The calculation of market samples was carried out using the formula n=4PQ/L2, with adjustments for a small population using n(adj)=Nxn/N+n (16). Prevalence data (89.1%) were obtained from the H9 positive results of LBM surveillance conducted by the Disease Investigation Center of Subang in Tangerang City, North Jakarta, and Bekasi City in 2021.

The calculations yielded 44 markets (93% CI, 7% error rate). The results were then divided proportionally among the three city areas to determine the number of market samples: 24 markets for Bekasi City, 17 for North Jakarta, and 15 for Tangerang City.

Samples will be collected in the form of swabs from the equipment at the sales locations of each vendor. The vendor's stall population sampled in 2018 was 180 stalls. The sample size was calculated using the formula mentioned earlier (95% CI, 5% error rate), resulting in a sample size of 87 vendors' stalls to be randomly selected from each market. Each stall will be subject to a pooled sampling approach, wherein a pool will consist of six equipment swabs taken from various locations, including (a) the cutting boards or processing tables after usage, (b) the wet cloths or rags, (c) the waste bins containing damp poultry waste, (d) the de-feathering machines, (e) the baskets holding cut chicken (moist inner parts), and (f) the tables where chicken carcasses were displayed (or meat containers).

Additionally, tracheal and cloacal swab samples will be collected from broiler chickens in conjunction with the collection of vendors' equipment swabs. This research is confined to broiler chicken strains, primarily due to their widespread consumption and sale by vendors. Notably, broiler chicken farms do not implement AI vaccination, making it possible to distinguish whether the infection originates from the farm or has been circulating within the environment. The sample size was calculated using the earlier formula (94% CI, 6% error rate). These calculations yielded 124 broiler chickens, from which tracheal and cloacal swab samples were randomly taken across each market. Two broiler chickens were selected from each vendor to obtain the swab samples, with each chicken contributing to a single pooled tracheal and cloacal swab.

Questionnaires

Data were collected using a questionnaire to gather information regarding factors associated with H9 virus contamination. The questionnaire underwent testing with a sample of 20 individuals before distributing among the study's target group respondents. The validity and reliability of the questionnaire were assessed using IBM SPSS Statistics for Windows version 25.0. The validity test employed the Pearson Product Moment correlation method, while the questionnaire's reliability was evaluated using the Alpha-Cronbach technique. The questions were valid, showing $p < 0.05$, and highly reliable, with a Cronbach's alpha value of >0.6 (0.636).

Diagnostic Methods

The diagnosis of the H9 virus was conducted using the real-time Reverse Transcriptase Polymerase Chain Reaction (rRT-PCR) method. RNA extraction was performed using the PureLink™ Viral RNA/DNA Mini Kit (Invitrogen Cat No. 12280050). The extracted RNA was subsequently amplified to detect the H9 subtype using rRT-PCR. The primer sequences and probes utilized for H9 subtype detection were sourced from AAHL (Geelong, Australia). The master mix kit employed was the SensiFAST™ SYBR® Lo-ROX One-Step Kit (Bioline Bio-74005 500rx). The testing procedure followed the Standard Operational Procedure for AI Virus Detection established by the Directorate General of Animal Husbandry and Health, Ministry of Agriculture (17).

Data Analysis

The data analysis encompasses univariate and bivariate analyses conducted using IBM SPSS Statistics for Windows version 25.0. Univariate analysis is intended to provide an overview of the frequency distribution for categorical variables such as market identity, poultry factors, stall facilities, and handling of sick birds. Bivariate analysis, on the other hand, aims to determine whether each independent variable exhibits a relationship or significance with the dependent variable. It is achieved by applying the Chi-Square test and calculating the Odds Ratio (OR). A multivariable logistic regression model was employed, following reference (18), using Statistix 9.1 to identify factors influencing the occurrence of H9 virus contamination.

Results and Discussion

Univariate analysis

Approximately 47.1% of the sold chickens originated from DKI Jakarta, while 33.3% came from West Java. Only 2.3% of vendors sourced chickens from Central Java and 17.2% from Banten. The chickens being sold were confirmed to be free from illness symptoms (93.1%) and displayed a clean appearance. Notably, most vendors (66.7%) said they would return chickens displaying disease signs to their suppliers. While it is possible to exchange dead birds with suppliers, based on interview responses, a significant proportion of vendors still discard them as waste (60.9%). There remains a need for

enhanced education concerning AI. It would better equip vendors to understand the clinical symptoms indicative of the virus and the associated risks for poultry and humans.

Of the 87 individuals surveyed, sixty-six vendors (75.9%) sold live poultry and carcasses, while 21 exclusively dealt with carcasses. The latest profiling results indicate a reduction in the number of vendors, attributed to various factors such as market regulations prohibiting the provision of live poultry holding cages, market renovations, and a decrease in vendors due to the Covid-19 pandemic's impact. The sale of live birds intended for home slaughtering (39.1%) saw a daily average of fewer than 15 birds, primarily because buyers often prefer slaughtering at the stall, thus opting for carcasses. Among those surveyed, the highest daily number of carcasses sold (49.4%) was less than 100, reflecting a decline in people's purchasing power.

As many as 19.5% of the vendors' stalls taken as a sample had poultry holding cages and 56.3% placed chickens in holding cages made of plastic or bamboo. Most vendors have implemented poultry separation based on species and supplier (66.7%). These holding cages can be situated adjacent to vendors' stalls (66.7%) or allocated to a designated area outside the stalls (10.3%). In cases where the holding cages are separate from the vendors' stalls, they often come equipped with chicken slaughter facilities, thereby designating the stalls solely for purchasing and selling carcasses. For vendors exclusively selling carcasses, slaughter typically occurs at dedicated poultry slaughterhouses.

Only 43% of vendors have implemented the separation of slaughtering and carcass processing, along with the usage of distinct tools for each area. Around 88.5% of vendors employ ceramic tables without additional mats for serving carcasses, while all use wooden cutting boards. Cleaning of the stalls takes place before and after sales activities using water and detergent. Nearly all vendors (> 95%) separate the placement of meat and offal, and approximately 69% segregate them by species. Overall, stall conditions are generally clean and free from pests. Vendors also prioritize safety by utilizing personal protective equipment (PPE) such as boots and aprons (65-75%). Roughly 70% of vendors utilize dedicated sinks for washing carcasses, with 80-90% of stalls equipped with running water. However, there is room for improvement in educating vendors about meat hygiene and sanitation, as only 57% currently apply such practices.

Prevalence of H9N2 in LBMs

The prevalence of H9 virus contamination at the LBM level in Tangerang City, North Jakarta, and Bekasi City in 2022 was recorded at 77.27% (93% CI, α 7%), while the prevalence at the vendors' stall level was 51.72% (95% CI, α 5%), as illustrated in Table-1. LBMs have long been suspected as a primary source of human infection with AI viruses. Numerous patients with diseases attributed to H5N1 and H7N9 infections have contracted them through indirect exposure to infected birds or via aerosols generated by the poultry slaughter process within markets (12).

Table 1. The prevalence of H9 virus contamination at the LBM and vendors' stalls level in Tangerang City, North Jakarta, and Bekasi City.

No	Sample	PCR H9	Tangerang	North Jakarta	Bekasi	Total
1	LBM	Positive	9	14	11	34
		Negative	6	3	1	10
		Total	15	17	12	44
		%	**60.00**	**82.35**	**91.67**	**77.27**
2	Vendors'	Positive	15	18	12	45
	stalls	Negative	15	15	12	42
		Total	30	33	24	87
		%	**50.00**	**54.55**	**50.00**	**51.72**
3	Trachea	Positive	6	6	6	18
		Negative	17	16	11	44
		Total	23	22	17	62
		%	**26.09**	**27.27**	**35.29**	**29.03**
4	Cloaca	Positive	2	2	3	7
		Negative	21	20	14	55
		Total	23	22	17	62
		%	**8.69**	**9.09**	**17.65**	**11.29**

The prevalence of the H9 virus in tracheal swabs was 29,03%, higher than in cloacal swabs, recorded at 11.29% (94% CI, α 6%). This observation is consistent with the findings of Peacock et al. (4), who suggested that LPAIV in chickens tends to exhibit more significant respiratory tropism, although certain strains also demonstrate gastrointestinal tropism. Respiratory and contact transmissions likely represent the primary routes of H9N2 transmission, and the emergence of partial respiratory transmission may have initially developed as an avian adaptation that subsequently influences zoonotic transmission implications.

Bivariate analysis of risk factors at the vendors' stalls level

Initially, the sampling targeted vendors' stalls equipped with live poultry holding cages and engaged in the on-site slaughtering of broiler chickens. The subsequent reduction in the number of vendors and the imposition of live poultry prohibition at the market prompted the extension of sampling to vendors exclusively selling broiler chicken carcasses. This situation necessitated the separate execution of bivariate analysis for vendors with live poultry holding cages and those specializing in carcass sales. The sampling encompassed 87 vendors' stalls, comprising 66 vendors with cages and 21 vendors selling carcasses.

The risk factors for H9 virus contamination in 66 vendors' stalls within live poultry markets withholding cages are detailed in Table-2 and Table-3. Among the risk factors influencing H9 virus contamination in LBMs, those with a significant p-value ($p < 0.05$) and relative risk (RR) include positive results from equipment swab samples ($p = 0.000$), positive results from both equipment and broiler swabs ($p = 0.000$), and the utilization of a carcass sink ($p = 0.031$; OR 3.451). A positive outcome in the equipment swab indicates the presence of H9 virus contamination from the vendor's equipment and the broiler slaughter process conducted at the vendor's stall. The RR value of 2.556 suggests that the risk of detecting the H9 virus in equipment is 2.556 times higher than in broilers. The risk factor about the source of the virus originating from broilers yielded insignificant results ($p = 0.356$), indicating that the detected H9 virus in broilers potentially originates from the transportation process and exposure to live poultry holding cages. Bertran et al. (19) stated that the AI virus could be airborne during the slaughter of infected poultry in LBMs, reaching distances of up to 80 cm. Markets solely vending carcasses or live poultry, without on-site slaughtering, significantly diminish the likelihood of H5 virus infection (OR = 0.2, 95% CI 0.1-0.5) (20).

Carcass sinks' utilization exhibited the highest significance level ($p = 0.031$) among the risk factors across other sanitation and hygiene categories. The association factor's strength for carcass-specific sinks stood at 3.451, signifying that H9 virus contamination was 3.451 times more likely in vendors employing carcass-specific sinks than those not using such facilities. The risk of H9 virus contamination in vendors using carcass sinks is 1.850 times higher (RR 1.850) than in vendors who do not use sinks. Vendors employ these carcass sinks continuously without changing the water after each chicken is slaughtered, potentially creating a conduit for virus transmission. Vendors should prioritize the upkeep of sink cleanliness to curb the widespread transmission of H9 virus contamination to other equipment.

The bivariate analysis for H9 virus contamination in the 21 stalls exclusively selling carcasses indicates that none of the risk factors from the poultry and sanitary hygiene categories significantly impacted H9 virus contamination, as the p-value exceeded 0.05. All the identified risk factors appear to exert a balanced influence on H9 virus contamination at the level of vendors' stalls.

Table 2. Risk factors of H9 viruses contamination for vendors' stalls who have live poultry holding cages and slaughter broiler chickens (poultry)

No	Variables		H9		Total	%	Bivariate			
			Pos	Neg			Chi Square	P	OR	RR
1	Market location	Tangerang	12	13	25	48	1.511	0.219		
		North Jakarta	16	8	24	66.7	1.276	0.259		
		Bekasi	10	7	17	58.8	0.015	0.904		
2	Sample type	Equipment	20	0	20	100	18.726	0.000**	-	2.556
		Broiler	2	0	2	100	0.256	0.613		
		Both	16	0	16	100	13.354	0.000**	-	2.217
3	Live poultry trading volume per day	<15	16	16	32	50	1.460	0.227		
		15-30	2	0	2	100	0.256	0.613		
		>30	8	2	10	80	1.465	0.226		
		0	12	10	22	54.5	0.124	0.725		
4	Carcass trading volume per day	<100	15	15	30	50	1.292	0.256		
		100-200	14	11	25	56	0.041	0.840		
		>200	9	2	11	81.8	3.176	0.075		
5	Poultry origin	West Java	14	10	24	58.3	0.009	0.925		
		Central Java	2	0	2	100	0.256	0.613		
		Jakarta	17	10	27	63	0.543	0.461		
		Banten	5	8	13	38.5	2.421	0.120		
6	Clinical signs of AI	No.	34	27	61	55.7	0.342	0.559		
		Yes	4	1	5	80				
7	Treatment of sick bird	Slaughtered and sold	7	6	13	53.8	0.092	0.761		
		Returned	22	17	39	56.4	0.053	0.818		
		Delayed slaughter	9	5	14	64.3	0.328	0.567		
8	Disposal of the dead bird	Buried	1	0	1	100	0.000	1.000		
		Thrown in the trash	28	18	46	60.9	0.674	0.412		
		Returned	9	10	19	47.4	1.138	0.286		
9	Knowledge of AI	Yes	17	16	33	51.5	0.992	0.319		
		No.	21	12	33	63.6				

Table 3. Risk factors of H9 viruses contamination for vendors' stalls who have live poultry holding cages and slaughter broiler chickens (hygiene and sanitation)

No	Variables		H9		Total	%	Bivariate			
			Pos	Neg			Chi-Square	P	OR	RR
1	Poultry separated in holding cages	Yes	26	20	46	56.5	0.069	0.793		
		No	12	8	20	60.0				
2	Slaughter location	Inside the stall	34	22	56	60.7	0.763	0.382		
		The separated area inside the market	2	4	6	33.3	0.684	0.408		
		Slaughter facility near the market	2	1	3	66.7	0.000	1.000		
		Slaughter facility far from the market	0	1	1	0.0	0.024	0.877		
3	Separation of slaughtering and carcass processing	Yes	16	11	27	59.3	0.053	0.818		
		No	22	17	39	56.4				
4	Different equipment in slaughtering and carcass processing	Yes	16	10	26	61.5	0.276	0.599		
		No	22	18	40	55.0				
5	Display table for carcass made from	Ceramic	34	24	58	58.6	0.007	0.935		
		Wood layered with plastic	1	0	1	100.0	0.000	1.000		
		Stainless steel	3	4	7	42.9	0.184	0.668		
6	Carcasses are placed directly on the table	No	6	6	12	50.0	0.345	0.557		
		Yes	32	22	54	59.3				
7	Carcasses are placed by species	Yes	26	20	46	56.5	0.069	0.793		
		No	12	8	20	60.0				
8	Pest in the stall	No	13	9	22	59.1	0.031	0.860		
		Yes	25	19	44	56.8				
9	The stall located in the specific meat area	Yes	28	21	49	57.1	0.015	0.904		
		No	10	7	17	58.8				
10	Stall location	In the middle of the market	26	17	43	60.5	0.422	0.516		
		Near entry of the market	7	7	14	50.0	0.418	0.518		
		Others	5	4	9	55.6	0.000	1.000		
11	PPE	Yes	26	22	48	54.2	0.837	0.360		
		No	12	6	18	66.7				
12	Wash hands before-after handling the carcass	Yes	14	12	26	53.9	0.244	0.621		
		No	24	16	40	60.0				
13	Carcass sink	Yes	32	17	49	65.3	4.654	0.031*	3.451	1.850
		No	6	11	17	35.3				
14	Carcass sink equipped with running water	Yes	34	27	61	55.7	0.342	0.559		
		No	4	1	5	80.0				
15	Knowledge of hygiene and sanitation	Yes	22	16	38	57.9	0.004	0.951		
		No	16	12	28	57.1				

Model of H9N2 contamination in vendors' stalls

The outcomes of the multivariate logistic regression analysis concerning H9 virus contamination in LBM vendors' stalls are presented in Table-4. Employing a convergence criterion of 0.10 and a confidence level (CI) of 95%, the resultant model equation was derived as follows: Logit P (H9=1 | x) = 0.29924 + 1.58691 CARCASS_SINK - 2.42176 PPE. This logistic regression model can assess the likelihood of H9 virus contamination in vendors' stalls at the LBMs in Jakarta, Tangerang, and Bekasi, contingent on adherence to the risk factors about using PPE and carcass sinks. The OR values of each variable included in the model are illustrated in Table-5.

Table-4: Multivariate logistic regression analysis of H9 virus contamination in LBM vendors' stalls

Variabel	Koefisien	Std Error	Coef/Se	P value
Constant	0,29924	0,53847	0,56	0,5784
PPE	-1,42176	0,64391	-2,21	0,0272
Carcass_sink	1,58691	0,57147	2,78	0,0055
Deviance		107,54		
P-value		0,0427		
Degrees of Freedom		84		

Table-5: Variable OR values in the H9 virus contamination model in vendors' stalls

Variabel	95% C.I. Lower Limit	Odds Ratio	95% C.I. Upper Limit
PPE	0,07	0,24	0,85
Carcass_sink	1,59	4,89	14,98

The outcomes of the logistic regression analysis presented in Table-4 and Table-5 demonstrate that the risk factor that amplifies the incidence of H9 contamination is using a carcass sink (β 1.58691; OR 1.59). Conversely, using PPE decreased the likelihood of H9 contamination due to the negative β value (-1.42176) and an OR value less than 1 (0.07). The resulting model has undergone the Hosmer-Lemeshow goodness-of-fit test, indicating a model sensitivity of 80% and a specificity of 43.24%.

The utilization of PPE by vendors yields a p-value of 0.0272, signifying a noteworthy correlation with H9 virus contamination. The nature of this factor's association is negative (OR 0.24), implying that the adoption of PPE diminishes H9 virus contamination on vendors' equipment. PPE, such as aprons and boots, protects vendors against viral exposure through physical contact. It is important to note that the virus can also spread through the air during the slaughter of infected poultry in LBMs, reaching distances of up to 80 cm (19). Markets that solely vend carcasses and live poultry without on-site slaughtering significantly decrease the risk of H5 virus infection (OR = 0.2, 95% CI 0.1-0.5) (20).

Carcass sinks display a significant predictive relationship (p = 0.0055) concerning the incidence of H9 virus contamination in vendors' stalls. The magnitude of the associated factor for carcass sinks stands at 4.89, signifying that the occurrence of H9 virus contamination in vendors' stalls employing carcass sinks is 4.89 times higher than those not utilizing such sinks. These carcass sinks are often employed continuously without water replacement, such as after each chicken slaughtering, potentially serving as a conduit for virus transmission. Vendors should prioritize the sanitation of sinks to curtail the broader dissemination of H9 virus contamination to other equipment.

Conclusion

The prevalence of H9 virus contamination at the LBM level in Tangerang City, North Jakarta, and Bekasi City was 77.27% (93% CI, α 7%) in 2022, while at the vendors' stall level, it stood at 51.72% (95% CI, α 5%). The risk factors for H9 virus contamination with a significant p-value ($p < 0.05$) include positive results from equipment swab samples (p = 0.000), positive results from both equipment and broiler swabs (p = 0.000), and the utilization of carcass sink (p = 0.031; OR 3.451). The multivariate analysis highlights that the risk factor contributing to the escalation of H9 contamination is the use of carcass sinks, whereas PPE like aprons and boots play a role in mitigating H9 contamination.

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Conflict of Interests

The authors declare that they have no competing interests.

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