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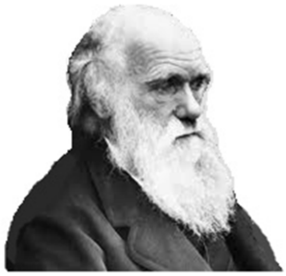

World News of Natural Sciences

An International Scientific Journal

WNOFNS 68 (2026) 286-297 EISSN 2543-5426

Reducing the Risk of Disease Spread in Poultry Through Hygiene and Biosecurity Practices in Imo State, Nigeria

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ABSTRACT

Disease outbreaks remain a major constraint in poultry production, particularly where farm-level hygiene and biosecurity compliance are suboptimal. This study assessed the influence of biosecurity level and management practices on disease incidence and mortality rate in commercial, semi-intensive, and backyard poultry farms in Imo State, Nigeria. A total of 100 poultry farms were categorized into low, moderate, and high biosecurity levels based on compliance scores. Farm observations, farmer interviews, and available farm health and production records were used to assess biosecurity practices, disease incidence, and mortality. Disease incidence (%) and mortality rate (%) were analyzed using a Generalized Linear Model (GLM) with biosecurity level, footbath use, visitor restriction, and farm type as explanatory factors. Correlations among biosecurity score, disease incidence, mortality, and flock size were also evaluated using Pearson's method. Biosecurity level had a significant effect on both disease incidence ($t = 15.10$, $p < 0.001$) and mortality rate ($t = 7.50$, $p < 0.001$). Farms with high biosecurity recorded 4.12 percentage points lower disease incidence and 1.37 percentage points lower mortality than moderate-level farms, whereas low-biosecurity farms showed 8.80 percentage points higher disease incidence and 3.25 percentage points higher mortality than high-biosecurity farms. Absence of footbaths increased disease incidence ($p = 0.029$), while farm type had a significant effect on disease incidence in semi-intensive systems. Biosecurity score correlated negatively with disease

(Received 11 August 2026; Accepted 09 September 2026; Date of Publication 10 September 2026)

incidence ($r = -0.83$, $p < 0.001$) and mortality ($r = -0.63$, $p < 0.001$). Enhanced biosecurity compliance was associated with reduced disease and mortality risks in poultry farms, emphasizing the importance of integrated hygiene measures such as entry disinfection, movement control, waste management, and pest control. Adoption of effective biosecurity practices may also reduce antimicrobial use and associated antimicrobial-resistance risks in poultry systems.

***Keywords*:** Biosecurity, poultry health, hygiene practices, disease incidence, mortality rate, farm management, Imo State

1. INTRODUCTION

Poultry production plays an important role in food security, employment generation, household income, and the provision of affordable animal protein, particularly in developing countries such as Nigeria. However, the productivity and profitability of poultry enterprises are continually threatened by infectious diseases. Disease outbreaks can result in increased mortality, reduced growth and egg production, higher expenditure on medication and vaccination, and substantial economic losses to farmers. According to Conan et al. (2012), poultry production systems in developing countries are particularly vulnerable to infectious diseases because of inadequate biosecurity, poor husbandry practices, and frequent movement of birds, people, and materials between production units. Studies in Nigeria also document similar vulnerabilities. Nwanta et al. (2020) reported low biosecurity knowledge among farmers in Southeast Nigeria, while Oyekunle and Ogunleye (2023) found high disease prevalence linked to poor farm hygiene in Southwest Nigeria. These gaps highlight the urgent need to assess current hygiene and biosecurity practices in poultry farms in Imo State. The increasing intensification of poultry production, which involves keeping large numbers of birds in relatively confined spaces, can further increase opportunities for the introduction and rapid transmission of infectious agents (Vougat Ngom et al., 2025).

Biosecurity is widely regarded as one of the most important approaches to preventing the introduction and spread of infectious diseases in poultry production. It encompasses a combination of measures designed to prevent pathogens from entering a farm, limit their movement within the farm, and reduce their transmission to other farms. Cardona and Kuney (2002) identified isolation, traffic control, cleaning, and disinfection as important components of effective poultry biosecurity. Similarly, Collett et al. (2019) emphasized the importance of disease prevention, bioexclusion, surveillance, and biocontainment in poultry production systems. Disease-causing organisms can enter poultry farms through several routes, including infected birds, contaminated feed and water, farm workers, visitors, equipment, vehicles, rodents, insects, and wild birds. Poorly managed poultry litter, carcasses, and other biological wastes can also provide opportunities for pathogens to persist and spread within the farm environment. Effective hygiene and biosecurity therefore require a combination of measures rather than reliance on a single intervention. Mohammed (2024) emphasized the importance of infrastructure, worker hygiene, access control, cleaning and disinfection, litter and waste management, and pest control in poultry biosecurity. The importance of these practices is particularly evident in developing countries, where smallholder and medium-scale poultry producers may have limited access to biosecurity infrastructure and veterinary services. Conan et al. (2012), in a systematic review of backyard poultry production in developing countries, reported that inadequate biosecurity practices may increase the vulnerability of poultry populations to infectious diseases. The authors emphasized the importance of practical and context-specific interventions that can be adopted and sustained by poultry producers. Evidence from Nigeria demonstrates that deficiencies in biosecurity remain a significant concern. Ameji et al. (2012), in a study conducted among poultry stakeholders in Kogi State, Nigeria, reported that 92.9% of respondents did not use footbaths or hand-washing disinfection facilities, while many farmers obtained birds from live-bird markets or unknown sources. Such practices can increase opportunities for infectious agents to enter and spread within poultry farms. Biosecurity practices also vary considerably among poultry farms and production systems. Scott et al. (2018), in an assessment of Australian commercial layer and meat-chicken farms, reported differences in the implementation of biosecurity practices and identified gaps in areas such as equipment disinfection and other preventive measures. These findings demonstrate that the availability of biosecurity facilities does not necessarily guarantee consistent implementation. Recent research further demonstrates the importance of evaluating the actual implementation of biosecurity measures. Vougat Ngom et al. (2025), in a systematic review of biosecurity implementation in poultry farms across Europe and neighboring countries, reported substantial variation in the adoption of biosecurity measures among production systems and countries. Similarly, Kovács et al. (2025) highlighted the importance of understanding disease transmission routes and the role of biosecurity in reducing the spread of economically important poultry diseases. Biosecurity is also relevant to antimicrobial use and antimicrobial resistance. Inadequate disease prevention may increase farmers' reliance on antimicrobial treatments, potentially contributing to antimicrobial resistance. Jimenez et al. (2023) found evidence that biosecurity and water, sanitation, and hygiene interventions in animal agricultural settings can contribute to reductions in infection burden, antibiotic use, and antimicrobial resistance. Davies and Wales (2019) similarly emphasized the relationship between farm biosecurity, disease prevention, antimicrobial use, and antimicrobial resistance.

Despite the recognized importance of hygiene and biosecurity, challenges remain in translating recommended practices into routine farm management. Factors such as limited knowledge, financial constraints, inadequate infrastructure, poor compliance, unrestricted movement of people and birds, inappropriate waste disposal, and limited veterinary support may undermine disease-prevention efforts. Furthermore, farm-level evidence concerning the relationship between biosecurity compliance and measurable poultry health outcomes remains important for improving disease-prevention strategies in Nigeria.

Imo State, located in southeastern Nigeria, has an active poultry production sector involving commercial, semi-intensive, and backyard poultry enterprises. However, there is a need for more empirical information on the relationship between hygiene and biosecurity practices and poultry health outcomes among farms in the state. Such information can assist farmers, veterinarians, extension personnel, and policymakers in identifying practical measures for reducing disease risks. Therefore, this study assessed the influence of hygiene and biosecurity practices on disease incidence and mortality among poultry farms in Imo State, Nigeria. Specifically, the study evaluated the effects of biosecurity level, footbath use, visitor restriction, farm type, and flock size on disease incidence and mortality rate.

1.1. Research Question

To what extent do improved hygiene and biosecurity practices significantly reduce the incidence and spread of infectious diseases in poultry farms in Imo State, Nigeria?

1.2. Hypothesis

It was hypothesized that farms with higher biosecurity compliance would exhibit significantly lower disease and mortality rates compared with farms of moderate or low biosecurity status.

2. MATERIALS AND METHODS

2. 1. Study Area and Design

The study was conducted across selected poultry farms in Imo State, southeastern Nigeria, representing diverse production systems, including intensive, semi-intensive, and backyard systems. A cross-sectional study design was adopted between November 2025 and July 2026, combining direct farm observation with farmer interviews and analysis of available production and health records.

Farms were selected using stratified sampling to ensure representation across biosecurity levels and farm types. A total of 100 poultry farms were included in the study. Each participating farm had completed at least one production cycle under the management conditions assessed during the study period. The study focused primarily on commercial layer and broiler operations, as well as smaller-scale poultry enterprises, with flock sizes ranging from 300 to 5,000 birds per farm.

2. 2. Biosecurity Assessment and Classification

Biosecurity compliance was evaluated using a structured biosecurity questionnaire and farm-observation checklist focusing on conceptual, structural, and operational biosecurity measures and relevant farm characteristics (Collett et al., 2019, EFSA, 2023).

Conceptual/external biosecurity: Visitor restriction, vermin control, farm access control, and control of live-bird movement. Internal/structural biosecurity: Perimeter fencing, disinfection of housing, vehicle and equipment cleaning, waste management, and footbath use. Operational management: Vaccination schedule, veterinary supervision, feed storage, and water sanitation. Each parameter was scored on a binary scale: 1 = compliant, 0 = non-compliant.

The total biosecurity score per farm was computed as:

$$\text{Biosecurity Score (\%)} = [\text{Sum of “Yes” responses} \div \text{Total parameters}] \times 100$$

Based on the composite score, farms were categorized into three biosecurity levels: Low: < 50% compliance; Moderate: 50-75% compliance; High: > 75% compliance.

This classification allowed statistical comparison of farm health outcomes across varying levels of hygiene and biosecurity compliance.

2. 3. Disease Incidence and Mortality Data

Disease incidence (%) and mortality rate (%) were obtained from farm production and health records and verified through available veterinary records where applicable. Disease incidence represented the number of clinically affected birds during the production cycle divided by the total flock size, multiplied by 100. Mortality rate was calculated as the proportion of birds that died during the same period.

Farmers were asked to confirm the nature of recorded diseases as bacterial, viral, or parasitic where possible. However, only total disease-incidence and mortality percentages were used in the statistical models to capture overall health outcomes.

2. 4. Explanatory Variables

The primary explanatory variable was biosecurity level (Low, Moderate, and High). Additional management variables included:

Footbath use: presence or absence of disinfection footbaths at farm entry.

Visitor restriction: control of personnel entry (Yes/No).

Farm type: intensive, semi-intensive, or backyard system. Flock size: number of birds per farm, treated as a continuous covariate.

These factors were selected because they represent important components of poultry disease prevention and farm management.

2. 5. Statistical Analysis

All analyses were performed using RStudio version 4.5.1. Descriptive statistics were generated to summarize farm characteristics. To evaluate the influence of biosecurity and management practices on health outcomes, a Generalized Linear Model (GLM) with normal distribution and identity link function was fitted separately for disease incidence (%) and mortality rate (%) as dependent variables.

The model structure was:

$$Y_i = \mu + \beta_1(\text{Biosecurity Level}) + \beta_2(\text{Footbath Use}) + \beta_3(\text{Visitor Restriction})_4 + \beta_4(\text{Farm Type}) + \varepsilon_i$$

where: Y_i is the dependent variable for the ith farm, β represents the estimated effect of each explanatory variable, and ε_i represents the random error term.

Wald chi-square tests were used to assess the significance of main effects at $p < 0.05$. Pearson's correlation analysis was also conducted to examine linear relationships among continuous variables, including biosecurity score, disease incidence, mortality rate, and flock size.

Results were expressed as parameter estimates ($\beta \pm SE$), t-statistics, and p-values. Differences between biosecurity categories were interpreted in relation to the high-biosecurity group as the reference category.

2. 6. Ethical Considerations

Participation in the study was voluntary. The purpose of the study was explained to participating farmers or farm managers before data collection, and informed consent was obtained. Information obtained from participating farms was treated confidentially, and farm identifiers were not included in the analytical dataset.

3. RESULTS

3. 1. Effect of Biosecurity Level on Disease Incidence

Generalized Linear Model (GLM) analysis revealed a significant effect of biosecurity level on disease incidence ($p < 0.001$; Table 1). Farms with low biosecurity compliance recorded a marked increase in disease incidence ($\beta = 8.80 \pm 1.47$, $p < 0.001$), while those with moderate biosecurity experienced a 4.12 percentage-point higher incidence ($\beta = 4.12 \pm 0.83$, $p < 0.001$) compared with farms maintaining high biosecurity compliance.

The absence of footbaths was associated with higher disease incidence ($\beta = 2.50 \pm 1.13$, $p = 0.029$), whereas visitor restriction did not significantly influence disease incidence ($p = 0.359$). Farm type showed a significant overall association with disease incidence, driven by semi-intensive systems, which showed higher disease incidence relative to backyard operations; intensive production systems did not differ significantly from backyard operations.

Table 1. Effect of biosecurity level and management factors on disease incidence (%) in poultry farms.

Predictor	Estimate (β)	SEM	t-stat	p-value	Significance
Biosecurity level (overall)	—	1.41	15.10	< 0.001	***
Low vs High	+8.80	1.47	5.97	< 0.001	***
Moderate vs High	+4.12	0.83	4.96	< 0.001	***
Footbath use (Absent vs Present)	+2.50	1.13	2.21	0.029	*
Visitor restriction (No vs Yes)	-0.91	0.99	-0.92	0.359	NS
Farm type (overall)	—	—	—	—	**
Intensive vs Backyard	+1.41	0.81	1.74	0.086	NS
Semi-intensive vs Backyard	+2.28	0.83	2.75	0.0072	**

GLM model fit: Null deviance = 2528.6; Residual deviance = 834.1; AIC = 511.9.
Significance levels: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; NS = not significant ($p > 0.05$).
Reference categories: High biosecurity, Footbath present, Backyard system.

3. 2. Effect of Biosecurity Level on Mortality Rate

Table 2 represents the effect of biosecurity levels on mortality rate among poultry farms. A similar pattern was observed for mortality rate. Biosecurity level had a strong overall effect ($p < 0.001$), with low-biosecurity farms recording 3.25 percentage points higher mortality ($\beta = 3.25 \pm 0.82$, $p < 0.001$), while moderate-biosecurity farms showed a 1.37 percentage-point higher mortality rate ($\beta = 1.37 \pm 0.46$, $p = 0.0039$) relative to high-biosecurity farms. Neither footbath use ($p = 0.861$) nor farm type ($p = 0.533$) significantly influenced mortality. Visitor restriction was also not significantly associated with mortality ($p = 0.233$).

Table 2. Effect of biosecurity level and management factors on mortality rate (%) in poultry farms.

Predictor	Estimate (β)	SEM	t-stat	p-value	Significance
Biosecurity level (overall)	—	—	7.50	< 0.001	***
Low vs High	3.25	0.82	3.97	< 0.001	***
Moderate vs High	1.37	0.46	2.96	0.0039	**
Footbath use (Absent vs Present)	0.11	0.63	0.175	0.861	NS
Visitor restriction (No vs Yes)	-0.66	0.55	-1.20	0.233	NS
Farm type (overall)	—	—	—	—	NS
Intensive vs Backyard	0.28	0.45	0.63	0.533	NS
Semi-intensive vs Backyard	0.55	0.46	1.19	0.235	NS

GLM model fit: Null deviance = 419.30; Residual deviance = 258.61; AIC = 394.80. Significance levels: *** $p < 0.001$; ** $p < 0.01$; NS = not significant ($p > 0.05$). Reference categories: High biosecurity, Footbath present, Backyard system.

3. 3. Correlation among Continuous Variables

A strong negative correlation was observed between biosecurity score and both disease incidence ($r = –0.83$, $p < 0.001$) and mortality rate ($r = –0.63$, $p < 0.001$), indicating that higher biosecurity compliance was associated with reduced disease and mortality levels. Disease incidence and mortality rate were positively correlated ($r = 0.78$, $p < 0.001$), reflecting the expected relationship between disease burden and flock losses.

Table 3. Pearson correlation coefficients among biosecurity score, disease incidence, mortality rate, and flock size in poultry farms.

Variables	Biosecurity Score	Disease Incidence (%)	Mortality Rate (%)	Flock Size (birds)
Biosecurity Score	1.00	–0.829***	–0.627***	–0.13
Disease Incidence (%)	–0.829***	1.00	0.78***	0.08
Mortality Rate (%)	–0.627***	0.78***	1.00	–0.158
Flock Size (birds)	–0.13	0.08	–0.158	1.00

Pearson's product–moment correlation; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; n = 100 farms.

The correlations between flock size and biosecurity score, disease incidence, and mortality were weak and not statistically significant ($p > 0.05$), suggesting that within the study population, disease outcomes were more strongly associated with biosecurity compliance than with flock size.

4. DISCUSSION

This study demonstrated a strong association between biosecurity compliance and poultry health outcomes among the 100 poultry farms assessed in Imo State, Nigeria. Farms with higher biosecurity compliance recorded substantially lower disease incidence and mortality compared with farms operating at moderate or low levels of biosecurity. The findings support previous evidence that effective biosecurity practices can reduce opportunities for pathogen introduction, transmission, and persistence within poultry production environments (Cardona & Kuney, 2002; Collett et al., 2019).

The strong negative correlation between biosecurity score and disease incidence ($r = –0.83$) indicates that farms with better compliance with biosecurity measures tended to experience lower disease incidence. Similarly, the negative correlation between biosecurity score and mortality ($r = –0.63$) suggests that improved biosecurity was associated with reduced flock losses. These findings are consistent with evidence from Africa indicating that effective biosecurity can contribute to disease prevention and control in livestock production systems (Vougat Ngom et al., 2024).

The present results also revealed that farms with low biosecurity had 8.80 percentage points higher disease incidence than high-biosecurity farms, while moderate-biosecurity farms had 4.12 percentage points higher incidence. A similar pattern was observed for mortality, with low- and moderate-biosecurity farms recording 3.25 and 1.37 percentage points higher mortality, respectively, than high-biosecurity farms. These findings reinforce the importance of comprehensive biosecurity rather than reliance on individual disease-prevention measures.

This is consistent with FAO (2024) guidelines for African smallholders, which emphasize that single measures like footbaths are insufficient without access control, waste management, and pest control. Our finding that footbath use alone did not significantly reduce mortality aligns with this recommendation for integrated packages.

Footbath use was significantly associated with disease incidence but not mortality. Farms without footbaths had approximately 2.50 percentage points higher disease incidence than farms with footbaths. This finding suggests that entry disinfection may reduce the probability of pathogen introduction through contaminated footwear. However, the absence of a significant association with mortality indicates that footbath use alone may be insufficient to prevent within-flock transmission after an infectious agent has entered the farm. Effective biosecurity requires complementary measures, including personnel hygiene, quarantine, movement control, environmental sanitation, pest control, and appropriate waste management (Mohammed, 2024; Kovács et al., 2025). The lack of a significant effect of visitor restriction on disease incidence and mortality may reflect differences in the effectiveness of implementation. Restricting visitors may be beneficial only when accompanied by appropriate procedures for essential personnel, including use of protective clothing, footwear disinfection, hand hygiene, and controlled movement between poultry houses. Consequently, the presence of a visitor restriction policy does not necessarily indicate effective implementation.

The effect of farm type was limited. Semi-intensive farms recorded significantly higher disease incidence than backyard farms, whereas intensive farms did not differ significantly from backyard farms. This suggests that production system alone may not determine disease risk. Differences in vaccination, veterinary supervision, stocking density, farm hygiene, movement patterns, and other management practices may influence disease outcomes across production systems. Sindiyo et al. (2018) similarly reported variation in food safety, health management, and biosecurity characteristics across poultry farms operating along different levels of intensification.

The Nigerian findings reported by Ameji et al. (2012) provide additional evidence of biosecurity challenges in poultry production. The high proportion of poultry stakeholders without footbaths or hand-washing disinfection facilities and the sourcing of birds from live-bird markets or unknown sources demonstrate potential pathways through which infectious agents may enter poultry farms. These practices are particularly relevant when considering disease prevention in small- and medium-scale poultry production systems.

The relationship between biosecurity and antimicrobial use is also important. Poor disease prevention may increase dependence on antimicrobial treatments, which can contribute to the development and dissemination of antimicrobial resistance. Jimenez et al. (2023) reported that biosecurity and WASH interventions in animal agricultural settings can contribute to reductions in infection burden, antibiotic use, and antimicrobial resistance. These findings align with WHO (2023), which identifies improved farm biosecurity as a core strategy to reduce antimicrobial use and AMR in food animal production. Strengthening on-farm hygiene may therefore contribute to broader public health goals under the One Health approach. Davies and Wales (2019) similarly emphasized the role of farm-level disease prevention in addressing antimicrobial resistance.

The strong positive correlation between disease incidence and mortality ($r = 0.78$) further indicates that farms experiencing greater disease burdens also tended to experience higher flock losses. This relationship is biologically plausible because infectious diseases can cause direct mortality as well as indirect losses through reduced feed intake, growth, production, and increased susceptibility to secondary infections.

Overall, the findings demonstrate the importance of integrated biosecurity management in poultry production. Improving individual measures such as footbath use is beneficial, but greater disease-prevention benefits are likely to be achieved when multiple measures are implemented consistently. This is particularly important in Imo State, where poultry production occurs across commercial, semi-intensive, and backyard systems with varying levels of infrastructure and management.

4. 1. Limitations of the Study

This study has several limitations that should be considered when interpreting the findings.

First, the cross-sectional design limits the ability to establish temporal and causal relationships between biosecurity practices and disease outcomes. Although higher biosecurity compliance was associated with lower disease incidence and mortality, the findings should primarily be interpreted as associations. In addition, seasonal effects were not accounted for, yet disease dynamics in poultry are known to vary with climate. Oni et al. (2025) reported that outbreaks of respiratory and enteric diseases in humid tropical zones of Nigeria peak during the rainy season due to increased humidity and poor ventilation.

Future longitudinal studies should incorporate seasonal data to better understand temporal patterns of disease risk in Imo State, and should also include economic cost-benefit analyses.

Second, some disease and mortality information was obtained from farm records and farmer reports. Differences in record-keeping practices, disease recognition, and diagnostic capacity among farms may have introduced some degree of reporting bias. Where laboratory or veterinary confirmation was unavailable, disease classification relied partly on available farm records and farmer information.

Third, some biosecurity measures, including footbath use and visitor restriction, were assessed as binary variables. This approach does not fully capture the quality, frequency, or consistency of implementation. For example, the presence of a footbath does not necessarily mean that an appropriate disinfectant was used at the correct concentration or replaced at appropriate intervals.

Fourth, farms differed in production system and flock size. Although farm type and flock size were considered in the analysis, other factors such as vaccination effectiveness, stocking density, environmental conditions, feed quality, water quality, veterinary access, pathogen type, and antimicrobial use may also influence disease incidence and mortality.

Finally, the study was conducted among selected poultry farms in Imo State, and the findings may not necessarily be generalizable to all poultry farms in Nigeria. Nevertheless, the study provides useful farm-level evidence concerning the association between biosecurity compliance and poultry health outcomes.

5. CONCLUSIONS

This study demonstrated that biosecurity level was strongly associated with disease incidence and mortality among the 100 poultry farms assessed in Imo State, Nigeria. Farms with high biosecurity compliance recorded substantially lower disease incidence and mortality compared with farms with moderate or low biosecurity compliance. Biosecurity score was strongly and negatively correlated with both disease incidence and mortality, emphasizing the importance of preventive management in maintaining flock health.

Although footbath use was significantly associated with reduced disease incidence, it was not independently associated with mortality. This finding highlights the fact that individual biosecurity interventions should not be considered substitutes for comprehensive disease-prevention programmes. Effective biosecurity requires the coordinated implementation of access control, personnel hygiene, cleaning and disinfection, movement control, proper waste disposal, pest control, vaccination, and appropriate veterinary supervision.

Collectively, the findings support the importance of strengthening biosecurity compliance among poultry farmers in Imo State. Improved biosecurity may reduce disease occurrence, flock mortality, production losses, and reliance on antimicrobial treatments, thereby contributing to more sustainable poultry production and antimicrobial-resistance control.

Future studies should employ longitudinal designs and incorporate laboratory-confirmed disease diagnoses, detailed assessments of the consistency and quality of biosecurity implementation, antimicrobial-use records, and economic cost-benefit analyses. As demonstrated by Alhaji and Babalobi (2021) in North-Central Nigeria and Rushton et al. (2022) in LMICs, quantifying the economic returns of biosecurity can increase farmer adoption. Extension and training have also been shown to improve compliance, which may be critical for

Imo State farmers (Ogunremi & Oyekale, 2024). Such studies would provide stronger evidence regarding the effectiveness and economic value of specific biosecurity interventions in Nigerian poultry production.

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