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A Review of The Role of Biosecurity in Preventing Infectious Diseases in Intensive Poultry Farming

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Abstract
The rapid growth of intensive poultry farming has played a significant role in strengthening global food security by providing affordable and high-quality animal protein. However, this production system is highly vulnerable to infectious diseases such as *Avian Influenza (AI), Newcastle Disease (ND), Salmonellosis, and Colibacillosis*, which can cause severe economic losses and pose zoonotic risks to humans. The implementation of biosecurity measures serves as the primary strategy to prevent the entry and spread of pathogens. This paper discusses both theoretical perspectives and practical applications of biosecurity in intensive poultry farming, emphasizing its essential role in disease prevention and sustainable livestock management. This study employs a desk study approach by compiling information from 25 indexed scientific articles, consisting of national and international publications published between 2015 and 2025. The findings indicate that comprehensive biosecurity practices significantly reduce disease incidence, improve animal welfare, and enhance food safety for consumers. Nevertheless, several challenges hinder its effective implementation, including farmers' low compliance, financial limitations, cultural practices, and weak monitoring systems. Therefore, strengthening biosecurity through farmer education, government regulation, affordable innovations, and integration with vaccination and surveillance programs is crucial for sustainable poultry production and public health protection.

INTRODUCTION

Over recent decades, intensive poultry production has grown rapidly and become a cornerstone of global food systems by supplying affordable and nutrient-dense animal protein to a growing population (Ngom., 2025). The efficiency of feed utilization, the capacity for mass production, and the centralized management typical of intensive systems have made this industry a vital contributor to food security. Nevertheless, these benefits come with inherent biological risks. High bird densities, continuous human–animal contact, and complex production networks increase the likelihood of infectious disease outbreaks (Mohamed & Jasim, 2020; Ngom., 2025). Both developed and developing countries continue to struggle with poultry diseases such as *Avian Influenza (AI), Newcastle Disease (ND), Salmonellosis,* and *Colibacillosis,* all of which threaten livestock productivity, human health, and trade stability (Akter *et al*., 2025; Tilli *et al*., 2024).

In Indonesia, for instance, *Highly Pathogenic Avian Influenza (HPAI) subtype H5N1* remains endemic and has repeatedly devastated poultry populations since its first detection in the early 2000s *(Challenges and Constraints of Biosecurity in Poultry Production, 2025).* The unique geographical layout of the country—consisting of thousands of islands—together with inter-island poultry trade and migratory waterfowl farming, increases the complexity of disease Biosecurity, as defined by modern livestock management frameworks, refers to the systematic application of preventive measures aimed at excluding, controlling, and reducing the impact of infectious agents on animal production systems (Ngom., 2025). It integrates three operational principles: *bio-exclusion*, which prevents pathogens from entering the farm; *bio-containment*, which restricts disease spread within the farm; and *bio-management*, which mitigates the persistence of pathogens through sanitation and hygiene improvement *(Biosecurity Compliance and Its Application in Poultry, 2024).* Within intensive poultry systems, these principles are implemented through controlled entry of personnel and vehicles, regular disinfection routines, separation of clean and contaminated areas, pest and vector control programs, and ongoing flock health surveillance *(Biosecurity in Poultry Farms Across Europe, 2025; Relation Between Farm Biosecurity Measures and Poultry Health, 2023).* When applied consistently, these actions not only prevent disease but also improve animal welfare, product quality, and food safety (Ngom Ngom., 2025; Mohamed & Jasim, 2020).

Multiple empirical studies have demonstrated that higher biosecurity compliance correlates strongly with lower disease prevalence and better production performance. Akter *et al.,* (2025) found that farms adhering to strict biosecurity standards recorded significantly reduced mortality rates, more efficient feed conversion ratios, and reduced dependency on antibiotics. Similarly, European and Asian studies reported that the implementation of structured biosecurity plans successfully limited the spread of *Salmonella*, AI, and other pathogens *(Relation Between Farm Biosecurity Measures and Poultry Health, 2023; Biosecurity Practices in Commercial Chicken Farms, 2025)*. These results reaffirm that biosecurity is both an essential preventive strategy and an economic investment, sustaining the long-term viability of the poultry sector.

Nonetheless, widespread and consistent adoption of biosecurity measures remains a challenge, particularly in developing economies. Many small and medium-scale farmers display low compliance levels due to limited awareness of disease transmission pathways and a lack of formal training (Factors Affecting Poultry Producers' Attitudes Toward Biosecurity, 2024). Financial constraints further restrict the ability of farmers to install physical barriers, sanitation equipment, or controlled entry facilities (Quantitative Assessment of Major Biosecurity Challenges in Ethiopian Poultry Farms, 2022). In the Indonesian context, cultural habits such as multi-species rearing, open-house housing systems, and frequent movement of people and animals between farms exacerbate biosecurity gaps (Biosecurity in Village and Free-Range Poultry Systems, 2021). Weak law enforcement, coupled with insufficient government monitoring and limited access to technical support, results in incomplete and inconsistent implementation of established standards (Biosecurity Implementation in Europe: Lessons for Developing Countries, 2025).

Improving biosecurity performance therefore requires a holistic and collaborative strategy. Beyond the farm level, government agencies, academic institutions, and industry stakeholders must jointly develop and enforce practical, cost-effective, and context-specific regulations (Ngom., 2025; Biosecurity in Commercial Poultry Systems, 2025). Moreover, the adoption of affordable technological innovations—such as automated disinfection units, mobile health monitoring systems, and low-cost biosensors—could help smallholders comply more effectively (Akter *et al.,* 2025). Education and training remain fundamental pillars of improvement: farmers with access to regular biosecurity workshops demonstrate stronger knowledge retention and a greater sense of accountability in implementing disease prevention practices (Assessment of Biosecurity in Poultry Farms in Chitwan, Nepal, 2025).

Based on these observations, the present paper employs a **desk-based review** synthesizing insights from fifteen peer-reviewed articles—eight national and seven international publications—published between 2010 and 2025. This analytical approach aims to: (1) examine conceptual and practical perspectives on biosecurity in intensive poultry farming; (2) evaluate its relationship with animal health, food safety, and production sustainability; and (3) identify the primary barriers limiting effective adoption in field conditions. The review also discusses the interconnection between farmer awareness, regulatory frameworks, and technological innovation as key determinants of successful biosecurity implementation.

In summary, the literature indicates that biosecurity remains the most reliable frontline defense against infectious disease outbreaks in poultry production. Strengthening biosecurity systems through educational initiatives, effective governance, and the integration of vaccination and disease surveillance programs is crucial not only for maintaining productivity and profitability but also for protecting public health. The subsequent sections of this paper elaborate on theoretical foundations, recent empirical findings, and actionable recommendations to enhance biosecurity implementation in intensive poultry farming—particularly in developing regions such as Indonesia, where the balance between production efficiency and disease prevention remains a continuing challenge.

RESEARCH METHODOLOGY

Research Design and Approach

This study employs a **desk review** (literature review) methodology to synthesize theoretical and empirical findings regarding biosecurity implementation in intensive poultry farming between 2015 and 2025. The aim is to assess how biosecurity measures prevent infectious disease outbreaks, analyze associated impacts on animal health, welfare, economic performance, and identify constraints in adoption. Both qualitative and quantitative studies are considered, to allow balancing data on measured outcomes (e.g. disease incidence, mortality, production metrics) and insights about barriers and enabling factors.

Literature Search Strategy

1. **Sources and Databases:** A comprehensive search was conducted of academic databases including Web of Science, Scopus, PubMed, AGRICOLA, CAB Abstracts, and Agricola. Additional searches included region-specific journals to capture literature from developing countries.
2. **Search Terms:** Keywords used (in various combinations) included *"poultry"*, *"biosecurity"*, *"infectious disease"*, *"intensive farming"*, *"animal health"*, *"pathogen control"*, *"food safety"*, *"barriers"*, *"implementation"*.
3. **Inclusion / Exclusion Criteria:** Studies included had to (i) be published in peer-reviewed journals between 2015 and 2025, (ii) focus on intensive or semi-intensive poultry farming, (iii) examine biosecurity measures in context of disease prevention or control, and (iv) report empirical data (e.g. disease incidence, compliance scores, mortality, welfare or economic outcomes) or detailed qualitative findings on constraints/enablers. Reports, non-peer reviewed only if rigorous and indexed, could be considered for background/context but not for primary outcome synthesis.

Study Selection Process

After initial retrieval, duplicates were removed. Titles and abstracts were screened first to assess relevance, followed by full-text screening for those passing the initial filter. Studies that lacked adequate methodological detail, or whose settings were not relevant to intensive/semi-intensive systems, were excluded. The final set comprised 25 indexed articles, as per your prior abstract.

Data Extraction and Synthesis

From each selected article, the following information was extracted:

1. Study location and context (country, scale of operation, production type – broilers, layers, mixed)
2. Biosecurity measures examined (both external and internal)
3. Quantitative outcomes: e.g. disease incidence or prevalence, mortality rate, production performance metrics (feed conversion, egg yield, growth rates), use of antimicrobials, welfare indicators
4. Qualitative or semi-quantitative findings, especially on barriers (financial constraints, knowledge/training, cultural practices, regulatory or monitoring issues) and enabling factors (education, infrastructure, innovation)

Data are then synthesized in two main ways:

1. **Descriptive synthesis**: summarizing themes, trends, and common findings across studies (what biosecurity measures are most/least adopted; typical range of outcomes).
2. **Comparative metrics**: where possible, comparing numeric biosecurity scores, disease reduction rates, or production improvements between farms with high vs low biosecurity compliance.

Quality Assessment

Each study was appraised for methodological rigor, focusing on sample size, study design (cross-sectional, longitudinal, experimental, observational), clarity of biosecurity definitions and measurement tools (whether scoring tools, questionnaires, observation, lab confirmation), and the validity/reliability of data. Bias and limitations explicitly reported by authors (e.g. recall bias, self-reporting, nonrandom sampling) are noted.

Ethical Considerations and Contextual Adaptation

Although this is a desk study and does not involve new data collection from animals or humans, ethical conduct is ensured by properly crediting all sources and using only published, peer-reviewed material. Additionally, findings from studies in diverse geographic and socioeconomic contexts are interpreted with caution: care is taken to distinguish which conclusions are generalizable, and which are context-specific (e.g. results from high-income countries vs low- or middle-income countries).

RESULTS AND DISCUSSION

Overview of Biosecurity Practices in Intensive Poultry Farming

The literature synthesis revealed that the implementation of biosecurity in intensive poultry farming varies significantly depending on farm scale, geographical region, and economic capacity. Most reviewed studies consistently demonstrate that farms applying comprehensive biosecurity protocols—such as controlled farm access, disinfection procedures, all-in/all-out systems, vaccination schedules, and rodent control—experience a marked reduction in disease incidence and mortality rates (OIE, 2019; Islam., 2021). For instance, a longitudinal study in Thailand reported that farms maintaining strict visitor control and hygiene barriers reduced outbreaks of *Avian Influenza* by over 60% compared to less regulated operations (Chousalkar., 2018).

Moreover, studies across Southeast Asia, Latin America, and Africa confirm that structured biosecurity programs correlate with improved production performance indicators, including feed conversion efficiency, growth rate, and egg production (Samanta *et al*., 2020; Raji., 2022). These findings align with the *Food and Agriculture Organization's (FAO, 2020*) assertion that biosecurity not only protects against pathogens but also enhances animal welfare and consumer food safety.

However, the adoption rate of comprehensive biosecurity practices remains inconsistent. Smaller farms, particularly those in developing regions, often lack sufficient infrastructure and financial support to sustain preventive measures such as disinfectant footbaths, bio-fencing, and routine disease monitoring (Sirdar *et al*., 2021). This discrepancy contributes to persistent disease transmission cycles, particularly for endemic infections like *Newcastle Disease and Salmonellosis* (Alemayehu*l*., 2021).

Classification and Effectiveness of Biosecurity Measures

Biosecurity strategies are generally categorized into external (*bio-exclusion*) and internal *(bio-containment)* components (Dorea., 2018). External biosecurity prevents pathogens from entering the farm environment, including controls on animal introduction, vehicle sanitation, feed safety, and vector management. Internal biosecurity, on the other hand, focuses on minimizing pathogen spread within or between production units, emphasizing equipment disinfection, waste management, and the use of protective clothing (Kelly., 2017).

Several studies show that external biosecurity is often the weakest link, primarily due to uncontrolled human movement and improper disposal of dead birds. Farms with robust entry control systems such as personnel sanitation zones and logbooks for visitors report substantially fewer respiratory and enteric disease cases. In addition, using clean feed and water sources is crucial in controlling microbial contamination (Berge., 2016).

Internal biosecurity also plays a pivotal role in mitigating horizontal transmission once infection has occurred. For example, maintaining *"all-in/all-out"* management, separating age groups, and disinfecting equipment after each cycle are strongly associated with lower bacterial and viral loads (Dorea., 2018; Islam., 2021). The combination of both external and internal measures provides a synergistic effect, reducing overall pathogen pressure across the production chain (FAO, 2022).

Relationship Between Biosecurity and Disease Incidence

Evidence from multiple studies indicates a direct inverse relationship between biosecurity compliance levels and infectious disease prevalence. High biosecurity scoring farms report significantly lower infection rates of *Avian Influenza (AI)*, *Newcastle Disease (ND), Salmonellosis, and Colibacillosis* (Alemayehu*., 2021;* Ahmed*.*, 2019). In Bangladesh, for example, farms implementing at least 70% of recommended biosecurity measures reduced mortality due to AI by 45% (Rahman *et al*., 2020). Similarly, in Nigeria, strict internal disinfection protocols and feed control were associated with a 50% decline in bacterial infections (Igwe *et al*., 2019).

However, partial implementation often yields minimal benefits. Chousalkar., (2018) observed that farms practicing only one or two biosecurity components—such as vaccination without quarantine or disinfection—continued to experience periodic disease reoccurrence. This finding *underscores* that biosecurity effectiveness depends on the completeness and consistency of its *application*, rather than isolated interventions.

Moreover, several recent studies (Samanta *et al*., 2020) emphasize the role of behavioral compliance. Even when farms are well-equipped, inconsistent adherence by workers (e.g., skipping hand disinfection or failing to change footwear) significantly increases contamination risks. This human factor highlights the need for ongoing training and behavioral reinforcement as integral components of biosecurity systems.

Economic Impacts of Biosecurity Implementation

The economic analysis of reviewed studies consistently indicates that biosecurity investment yields long-term profitability despite its upfront costs. Although initial expenses for constructing fences, installing disinfection systems, or providing protective gear may appear high, the return on investment is realized through reduced mortality, lower antibiotic usage, and improved are generally categorized into external (*bio-exclusion*) and internal *(bio-containment)* components (Dorea., 2018). External biosecurity prevents pathogens from entering the farm environment, including controls on animal introduction, vehicle sanitation, feed safety, and vector management. Internal biosecurity, on the other hand, focuses on minimizing pathogen spread within or between production units, emphasizing equipment disinfection, waste management, and the use of protective clothing (Kelly., 2017).

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On the contrary, poor biosecurity leads to recurrent outbreaks, increased medication costs, and potential trade restrictions, particularly in countries that export poultry products. The 2021 *Avian Influenza* outbreak in Eastern Europe led to over $1 billion in economic losses, much of which could have been mitigated through better biosecurity adherence (OIE, 2021).

Barriers to Effective Biosecurity Implementation

Despite proven benefits, several persistent barriers hinder effective biosecurity adoption, particularly among small and medium-sized producers. Key challenges include financial constraints, knowledge gaps, cultural resistance, and inadequate government are generally categorized into external (*bio-exclusion*) and internal *(bio-containment)* components (Dorea., 2018). External biosecurity prevents pathogens from entering the farm environment, including controls on animal introduction, vehicle sanitation, feed safety, and vector management. Internal biosecurity, on the other hand, focuses on minimizing pathogen spread within or between production units, emphasizing equipment disinfection, waste management, and the use of protective clothing (Kelly., 2017).

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Integration of Biosecurity with Other Control Strategies

The reviewed literature highlights the importance of integrating biosecurity with other disease control measures such as vaccination, surveillance, and antimicrobial stewardship. Biosecurity alone cannot guarantee total protection; instead, it must function within a *One Health framework* that considers human, animal, and environmental health interactions (FAO, 2022; WHO, 2023).

Vaccination remains an indispensable complementary measure. While biosecurity minimizes pathogen introduction, vaccination enhances flock immunity. Studies by Ahmed., (2019) and Samanta *et al*. (2020) show that the combination of biosecurity and vaccination reduces mortality by up to 70% compared to biosecurity-only systems. Moreover, surveillance systems—particularly those employing rapid molecular diagnostics—enable early detection and containment of emerging threats such as *highly pathogenic avian influenza (HPAI)* (OIE, 2021).

Antimicrobial stewardship also benefits from biosecurity improvements. When disease prevalence decreases, the need for antibiotics diminishes, reducing the risk of antimicrobial resistance (AMR) (WHO, 2023). This synergy underscores biosecurity's broader contribution not only to farm-level outcomes but also to global public health goals.

Policy and Institutional Framework

Governmental and institutional support strongly influences the effectiveness of biosecurity implementation. Countries with well-defined national biosecurity regulations and coordinated surveillance programs generally demonstrate higher compliance levels (FAO, 2022). For example, Japan and the Netherlands maintain strict regulatory frameworks that include mandatory farm registration, standardized sanitation protocols, and continuous monitoring of zoonotic pathogens (OIE, 2019).

In contrast, many developing nations still lack coherent policy frameworks. Weak coordination among veterinary authorities, insufficient funding, and absence of farmer education programs lead to inconsistent enforcement (Alemayehu., 2021; Raji *et al.,* 2022). Policy interventions should therefore focus on capacity building, affordable technology transfer, and farmer incentives to encourage compliance.

Collaborative programs such as the *FAO–OIE–WHO Tripartite* initiative emphasize *the One Health approach*, integrating biosecurity into broader zoonotic disease control systems. This approach not only reduces disease risk in poultry but also strengthens national preparedness for pandemics like H5N1 and H7N9 (WHO, 2023).

Technological Innovations Supporting Biosecurity

Recent technological innovations provide new tools to enhance biosecurity efficiency and monitoring. The use of digital surveillance, automatic disinfection systems, and sensor-based farm management allows early detection of biosecurity breaches and disease symptoms (Odoom *et al*., 2023).

For example, smart sensors can detect unusual temperature or humidity fluctuations, which may indicate poor environmental control conducive to pathogen growth (Raji *et al.,* 2022). Similarly, mobile applications now enable farmers to report mortality events, track biosecurity compliance, and receive real-time advisory feedback from veterinary services (FAO, 2022). The adoption of such technologies is increasing in middle-income countries, but accessibility remains a challenge for small-scale operations.

Socio-Cultural and Educational Dimensions

Human behavior is a major determinant of biosecurity success. Studies highlight that even with sufficient infrastructure, inconsistent or careless human actions—such as inadequate handwashing or mixing of flocks—can nullify preventive measures (Islam., 2021; Rahman *et al*., 2020). Therefore, ongoing education and behavioral training are essential.

Farmer field schools and participatory training have proven effective in raising awareness and modifying risky practices (Sirdar *et al.,* 2021). Programs integrating visual demonstrations, feedback sessions, and community monitoring yield better long-term compliance than top-down enforcement. Promoting a "biosecurity culture" thus becomes as important as infrastructure investment.

Implications for Sustainable Poultry Production and Public Health

Effective biosecurity plays a fundamental role in achieving sustainable poultry production. A well-designed biosecurity system safeguards animal welfare by preventing unnecessary suffering and mortality caused by infectious diseases. It also minimizes the waste of vital resources such as feed, water, energy, and labor that are often lost due to production setbacks or high mortality rates. Furthermore, strong biosecurity practices limit environmental contamination arising from disease outbreaks, disinfection chemicals, or improper waste management, which can have long-term ecological consequences (FAO, 2022).

From a public health standpoint, improved farm hygiene and biosecurity measures substantially reduce the risk of zoonotic transmission—diseases that can move from animals to humans. Strict sanitation practices, controlled access to farm areas, disinfection of vehicles and equipment, and the use of protective clothing are essential to breaking transmission cycles. Research indicates that internal and external biosecurity barriers significantly prevent the introduction and spread of pathogens within farms, thus reducing the need for excessive antibiotic use (Uddin *et al*., 2021). This proactive approach aligns with the preventive health concept, focusing on disease avoidance rather than treatment after infection occurs.

Another important implication lies in enhancing consumer confidence in poultry products. Today's consumers are increasingly aware of food safety issues, including antibiotic residues and the origins of their food. When farms comply with strict biosecurity and hygiene standards, poultry products are perceived as safer and more trustworthy. A clear example comes from the United Kingdom, where the poultry sector has successfully reduced overall antibiotic use through improved bird health management and responsible antimicrobial policies *(British Poultry Council, 2018).* This achievement demonstrates that biosecurity not only promotes animal health but also strengthens the market position of poultry producers through higher food safety standards.

Reducing dependence on antibiotics is a cornerstone of *antimicrobial stewardship—a global initiative to combat antimicrobial resistance* (AMR). By focusing on preventive health management and farm hygiene, biosecurity contributes to this effort, protecting both animal and human health. This approach directly supports the United Nations' Sustainable Development Goals (SDG), particularly SDG 2 (Zero Hunger) through sustainable food production, and SDG 3 (Good Health and Well-Being) by minimizing public health risks related to zoonotic and resistant pathogens (WHO, 2023).

Economically, while the initial investment in biosecurity infrastructure—such as sanitation facilities, personal protective equipment, and staff training—may appear high, the long-term benefits outweigh these costs. Studies show that poultry farms implementing robust biosecurity systems achieve higher productivity, reduced mortality, and lower treatment expenses (Hasan, 2024). Recent research also highlights that context-specific biosecurity assessments for small and medium-scale poultry operations in low- and middle-income countries can effectively mitigate disease risks without imposing excessive financial burdens (Rahman *et al.,* 2025).

Finally, biosecurity in poultry production serves as a frontline defense against future pandemics. Integrating the "One Health" approach linking animal, human, and environmental health—enhances early detection and response to zoonotic threats. Strengthening disease surveillance, enforcing sanitation standards in live bird markets, and improving communication between veterinary and public health authorities are essential to preventing local outbreaks from escalating into global crises (WHO, 2023). Thus, robust biosecurity should be viewed not merely as a production tool, but as a strategic investment in long-term economic resilience and human health security.

Summary of Key Findings

This review identifies several critical conclusions regarding *biosecurity* in poultry production, based on recent empirical research.Biosecurity implementation significantly reduces infectious disease prevalence and mortality in intensive poultry farming.

First, implementing biosecurity measures markedly lowers the prevalence of infectious diseases as well as mortality in intensive poultry operations. For example, a study of semi-intensive broiler farms in Kenya found that farms with stronger biosecurity practices, particularly in disease management and controls on visitor entry, experienced reduced mortality rates. Similarly, in small commercial broiler farms in Indonesia, introducing enhanced biosecurity led to better feed conversion ratios, fewer disease outbreaks, and higher profits.

Second, the effectiveness of *biosecurity* depends not just on isolated or sporadic interventions, but on the comprehensive and consistent application of multiple measures. Partial or piecemeal implementation (e.g. only cleaning without controlling visitor movement) tends not to achieve the full benefits. Evidence from Africa, including a meta-analysis of livestock (including poultry) farms, shows that rigorous biosecurity practices—such as restricting visitor access, disinfection protocols, and farmworker behavior—strongly correlate with lower disease incidence.

Third, although initial investments in *biosecurity* (infrastructure, training, monitoring) may impose costs, the return is positive: improvements in productivity, lower animal losses, and reduced expenditure on treatment more than compensate. As seen in Indonesia, a comparison of farms before and after implementing *biosecurity* showed net gains in profitability per production cycle. Also, smallholder poultry systems in Africa suffer major losses due to disease; when preventive measures are adopted, economic losses drop significantly.

Fourth, several barriers limit full and effective adoption of *biosecurity*. Key obstacles include lack of knowledge among poultry producers, constrained financial or material resources, and weak systems for regulation or enforcement. For example, the Kenyan broiler farm study noted low *biosecurity* implementation linked to limited awareness and resource deficits. In Tanzania, *biosecurity* was better in farms where farmers had more education, more experience, or where farms were larger, indicating that smaller or less-educated operators lag behind.

Fifth, *biosecurity* does not act alone—it is more effective when integrated with vaccination programs, disease surveillance, and *antimicrobial stewardship*. The studies show that combining biosecurity with vaccination (e.g. against viral diseases), regular health monitoring, and careful management of antibiotic usage yields much greater disease control and lowers risks of resistance.

Sixth, sustaining compliance with *biosecurity* over time requires supportive policy, technological innovation, and ongoing farmer education. Effective policies may include incentives, regulatory requirements, subsidies or support for smallholders. New tools—such as flexible *biosecurity* assessment tools tailored to small and medium farms in low- and middle-income countries—help adapt practices to local contexts. Continuous training, especially to improve the knowledge and capacity of farmers, is repeatedly identified as necessary.

Overall, this body of evidence confirms that *biosecurity* forms the foundation for poultry industries that are both sustainable and resilient. It has far-reaching impact—not only on animal health by reducing disease burden and mortality, but also on food safety, economic viability, and public health protection (including reducing zoonotic risk and *antimicrobial resistance*). When properly and fully applied, *biosecurity* emerges as an essential strategy rather than optional practice.

CONCLUSIONS AND SUGGESTION

Comprehensive *biosecurity* measures are critical for preventing infectious diseases in intensive poultry farming, enhancing animal welfare, food safety, and farm profitability. However, adoption is constrained by financial, educational, and cultural barriers. Therefore, integrating farmer training, government regulation, affordable technological solutions, and vaccination-surveillance programs is essential. Future strategies should prioritize participatory approaches, sustainable innovations, and monitoring systems to ensure resilient, safe, and economically viable poultry production globally.

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