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Research Article

Risk Mitigation Model for Layer Farming Agribusiness in Penebel District, Tabanan Regency

Gede Mekse Korri Arisena[1,3*], Dwi Putra Darmawan[1,3], Ni Luh Made Indah Murdyani Dewi[1,3], Gede Wisnu Sahatmana[1], Keirrann Arthur Paskahadi[2], Gabriel Adam Salombe[2], I. Wayan Nico Fajar Gunawan[2,3], Putu Devi Jayanti[2], Romy Muhammad Dary Mufa[2], Putu Henrywaesa Sudipa[2]

[1]Study Program of Agribusiness, Udayana University, Denpasar, Indonesia; [2]Faculty of Veterinary Medicine, Udayana University, Denpasar, Indonesia; [3]Center of Excellence for Food Sovereignty, Udayana University, Denpasar, Bali, Indonesia.

Abstract | Various diseases in chicken farming pose significant risks and can result in substantial losses for poultry agribusinesses. In the Penebel Sub-district, disease is one of the most dominant risk factors, often leading to mortality and decreased productivity. The aim of this study was to develop a risk mitigation model for chicken farming agribusiness by analyzing disease-related risks, identifying the most vulnerable housing types, assessing the level of biosecurity implementation, and evaluating biosecurity management practices. The study was conducted in three selected villages viz., Jatiluwih, Senganan, and Babahan within Penebel Sub-district. A total of 60 chicken farms, each raising more than 3,000 chickens, were selected for data collection through questionnaires and on-site recording. Descriptive analysis was used to interpret the collected data. Laboratory examination of 38 dead chicken samples revealed that 68.42% (26/38) of deaths were due to *E. coli* infection, while 15.8% (6/38) were caused by *Citrobacter koseri* and 15.8% (6/38) by *Proteus* spp. The findings indicate that poultry disease risk in the Penebel Sub-district is influenced by environmental, managerial, sanitation, socioeconomic, and biosecurity factors. Effective mitigation requires structured biosecurity measures and proactive disease surveillance strategies.

Keywords | Risk, Poultry disease, Chicken farming, Agribusiness, Biosecurity, Microbiology

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***Correspondence** | Gede Mekse Korri Arisena, Study Program of Agribusiness, Udayana University, Denpasar, Indonesia; **Email:** korriarisena@unud.ac.id
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INTRODUCTION

Achieving sustainable food security has become a top priority on the global agenda, including in Indonesia. In response, the Indonesian government has intensified its focus on the food sector to ensure the availability and accessibility of nutritious food for its population. Among the key animal-based food sources, chicken eggs play a vital role in daily nutrition due to their affordability, accessibility, and high nutritional value—being rich in protein, vitamins, and minerals (Ibrahim *et al*., 2024; Lopulalan *et al*., 2024). As a consistent and reliable source of high-quality protein, layer farming presents strong business potential. Eggs remain a staple for meeting daily protein needs in both local and global markets. Moreover, the industry offers opportunities for diversification through value-added products such as organic and omega-3-enriched eggs, which can enhance market competitiveness. With this broad potential, the layer poultry agribusiness sector not only supports food security but also serves as a strategic contributor to income generation, social welfare, and regional economic development (Amicarelli *et al*., 2023; Kleyn and Ciacciariello, 2021; Medina-Cruz *et al*., 2024).

Disease transmission remains one of the most critical challenges in poultry farming, complicating control efforts and posing a serious threat to production efficiency. Chickens are particularly susceptible to a wide range of infections, which not only elevate treatment costs but also significantly reduce the profitability of poultry operations (Akintunde *et al*., 2015). Common poultry diseases include Avian Influenza (AI), Infectious Bronchitis (IB), Chicken Infectious Anemia (CIA), Fowl Pox, Infectious Bursal Disease (IBD), Lymphoid Leucosis, Inclusion Body Hepatitis (IBH), Salmonellosis, Chronic Respiratory Disease (CRD), Colibacillosis (*E. coli*), Spirochetosis, Coccidiosis, Aspergillosis, and Ascites. These diseases, caused by viral, bacterial, fungal, and environmental factors, lead to considerable production losses (Nawab *et al*., 2018). In addition, fluctuations in weather conditions can act as stressors that exacerbate chickens' vulnerability to disease outbreaks (Nyoni *et al*., 2019). Pathogenic diseases can spread rapidly among chickens via both direct contact and indirect means, such as contaminated equipment or environmental exposure, further complicating disease management and resulting in decreased production and financial losses (Serbessa *et al*., 2023).

The housing system in poultry farming plays a pivotal role in the control and spread of infectious diseases. A well-managed cage system, specifically designed to accommodate the behavioral and physiological needs of chickens, can significantly reduce the transmission of viral and bacterial pathogens (Erensoy *et al*., 2021). Adhering to proper cage management practices not only enhances animal welfare but also minimizes the spread of infections, thereby reducing losses associated with disease treatment and mortality (Syafar *et al*., 2021).

In addition to housing, the implementation of comprehensive biosecurity measures is critical for disease prevention in poultry farms. Keutchatang *et al*. (2021) emphasize the importance of optimizing farm-level biosecurity strategies to mitigate the risk of disease outbreaks, suggesting the classification of farms based on biosecurity performance scores. However, as Greening *et al*. (2020) note, the effectiveness of biosecurity measures can vary widely among farms, with some exhibiting low compliance despite high levels of disease risk. This variation highlights the urgent need for increased awareness and training among poultry farmers to ensure consistent and effective application of biosecurity protocols for improved disease control.

This study is essential for addressing the spread of poultry diseases on farms. By applying risk mitigation modeling and evaluating biosecurity practices, it provides valuable insights into effective disease risk management in chicken farming. The primary objective is to investigate, develop, and simulate a risk mitigation model tailored to poultry agribusiness, with the aim of enhancing disease control strategies and improving farm resilience against infectious outbreaks.

MATERIALS AND METHODS

Sampling

This study was conducted in Penebel Sub-district, Tabanan Regency, Bali Province, between February and November 2024. From the 17 villages within the sub-district, three were selected based on the highest number of layer chicken farmers: Jatiluwih, Senganan, and Babahan. The study specifically targeted layer chicken farms with flock sizes exceeding 3,000 birds.

According to the 2022 Livestock Business Report (USPET) from Tabanan District, a total of 60 farms met the inclusion criteria. All 60 farmers, representing the complete population of eligible farm owners from the selected villages, were included in the study through a census approach.

Methods

The sampling technique used in this study was a non-probability method known as saturated sampling, or the census method, wherein all members of the target population were included. Both primary and secondary data were utilized in the research. Primary data were collected through questionnaires and structured interviews with selected farmers. Secondary data were obtained from farm records, literature reviews (including books, theses, journals, and online sources), and official data from relevant institutions such as the Central Bureau of Statistics and the Tabanan District Agriculture Office.

The first research objective focused on identifying the incidence of chicken mortality caused by bacterial infections, which was confirmed through bacteriological laboratory analysis. Measurement was conducted by calculating disease prevalence relative to the total chicken population. The second objective aimed to assess farmers' understanding and implementation of biosecurity practices. This was measured by analyzing the relationship between the level of farmers' biosecurity knowledge and the risk factors contributing to bacterial disease outbreaks in poultry farming (Figure 1).

Bacterial Analysis

Tissue samples, including those from the lungs, heart, and small intestine, were collected aseptically from deceased chickens suspected of having bacterial infections. These samples were placed in sterile containers to prevent contamination. They were then transported under refrigerated conditions to the Laboratory of Veterinary Microbiology at the Faculty of Veterinary Medicine, Udayana University, for bacterial analysis.

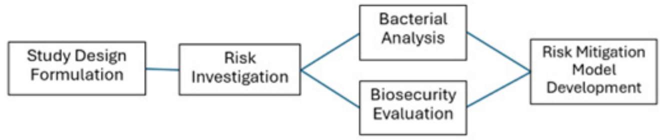

Figure 1: Study design of risk mitigation model.

Bacterial isolation was conducted by culturing the collected samples on both selective and non-selective media to promote the growth of potential pathogens. Identification of bacterial isolates involved the use of various agar media, including MacConkey Agar and Eosin Methylene Blue Agar (EMBA). Further biochemical characterization was performed using IMViC tests—namely Sulfide Indole Motility (SIM), Methyl Red (MR), Voges-Proskauer (VP), and Simmons Citrate (SC) tests—as described by Abu-Sini *et al.* (2023). Additionally, Gram staining was employed as a preliminary method to determine the morphological and structural characteristics of the bacteria.

Data Analysis

The analytical methods used in this study were quantitative analysis and qualitative analysis. Objective one in this study was analyzed using quantitative analysis of the prevalence of bacterial disease in chicken farms in Penebel District. Objective two was analyzed using qualitative analysis of farmers' understanding of Sanitation and Hygiene of cage management in chicken farming. Objective three was analyzed descriptively qualitatively based on the results of the analysis of objectives one and two. In objective three, it is expected to be able to build a risk mitigation model in the chicken farming business towards improving the welfare of farmers.

RESULTS AND DISCUSSION

Risk Identification of Poultry Disease in Chicken Farming Businesses in Penebel District

The risk of poultry diseases in chicken farms in Penebel Sub-district is influenced by environmental factors, chicken health, farm management, hygiene, sanitation, socioeconomics, and biosecurity. High humidity during the rainy season promotes pathogen growth. Poor hygiene, contaminated feed or water, overcrowding, and infected chicken transport increase disease spread. Inadequate health regulations and low-quality feed worsen the risk, potentially spreading diseases to humans. Strict biosecurity measures and integrated health programs are essential for risk reduction. Demographic data was obtained from 28 farmers in Babahan village, 22 farmers in Senganan village and eight farmers in Jatiluwih village. With a livestock population between 3,000 - 30,000 chickens. This study targeted 18 farmers with diverse populations with six farmers in each village.

The results of the veterinary bacteriology laboratory test of the samples used by the researchers can be seen in Table 1.

Table 1: Veterinary bacteriology laboratory test results.

Bacteria	Count	Percentage	Locations
E. coli	26	68.42%	Sanganan, Babahan
Citrobacter	6	15.79%	Sanganan
Proteus	6	15.79%	Sanganan, Babahan, Jatiluwih

The livestock mortality rate in the study area is relatively low, below 3%. Field observations and anatomical pathology results revealed that the deaths were caused partly by stress and partly by illness. Laboratory tests on dead chicken samples showed that most deaths (68.42%, or 32 out of 38) were due to *Escherichia coli* (*E. coli*) infection, while 15.8% (6 out of 38) were caused by *Citrobacter* and *Proteus*. The mortality rate on farms in Penebel Sub-district, ranging from 0.3% to 1%, remains low, which can be attributed to effective biosecurity measures.

E. coli can cause Colibacillosis, the main causes of economic losses in the poultry industry worldwide. Airsacculitis, peritonitis, polyserositis, and septicaemia are the most common lesions related to colibacillosis. Colibacillosis is usually considered as a secondary illness that develops after a primary respiratory pathogen infection and/or disruptive conditions in the environment (Vandekerchove *et al.*, 2004). *E. coli* is part of the normal flora but can become pathogenic when its numbers increase, often due to poor hygiene and sanitation, such as contaminated water. Similarly, polluted water can also be a source of infection by *Citrobacter* species (Witaningrum *et al.*, 2022). *E. coli* strains are utilized as markers of faecal contamination in food, even though most of them are not harmful, between 10 and 15% of intestinal coliforms are pathogenic and opportunistic serotypes, which can cause a variety of lesions, especially in immunocompromised hosts including chickens (Hassan *et al.*, 2014).

Numerous *Citrobacter* species have been found in the gut microbiota of animals, including humans, as well as in a range of environments, such as soil and water (Bennett *et al.*, 2019). Like other Enterobacteriaceae, *Citrobacter* species are frequently transmitted by the fecal-oral pathway. *Citrobacter* species are zoonotic pathogens that humans can contract from chickens while handling eggs, processing cooked or raw meat and handling carcasses in an abattoir (Hasan *et al*., 2019). *Citrobacter* in poultry is relatively uncommon compared to other bacterial pathogens like *E. coli, Salmonella*, or *Clostridium*. However, it can act as an opportunistic pathogen under certain conditions, especially in immunocompromised birds or in farms with poor biosecurity and hygiene.

Proteus is a common intestinal bacterium that can cause urinary tract infections in humans. Chickens' digestive tracts may harbor this bacterium, making improper handling of poultry products during slaughter and raw poultry carcasses a significant source of human infection (Nemati, 2013). Like *Citrobacter*, these bacteria are also uncommon causes of disease in poultry. They primarily act as normal flora in the chicken's intestines and typically do not cause illness unless triggered by poor sanitation, stress, or weakened immunity.

Biosecurity procedures should be implemented with the aim of preventing the entry and dissemination of infectious agents throughout the poultry production chain by enhancing the application of Good Manufacturing Practices (GMPs), Good Hygiene Practices (GHPs), and other biosecurity principles, as well as food safety assurance systems (Sture *et al*., 2013). In Penebel Sub-district, biosecurity implementation varies by farm size. Large farms apply better biosecurity measures, such as cage sanitation, restricted access, feed and water monitoring, and regular vaccinations against diseases like Newcastle Disease (ND) and Avian Influenza. Meanwhile, small or household farms often face challenges due to limited funds, knowledge, and facilities, resulting in inconsistent cage cleaning and vaccination, increasing the risk of disease transmission (Zerssa *et al*., 2021).

Another important aspect of biosecurity is the control of feed and water used. Large farms usually use quality-tested feed and ensure that water sources are free from contamination. However, on small farms, it is common to find the use of poor-quality feed or contaminated water, which can be a medium for spreading disease-causing microbes. In addition, access to animal health services, including vaccination and treatment, is more limited on small farms, especially those in remote areas. Biosecurity management involves not only technical implementation but also farmer education. The government and relevant agencies have increased extension efforts to raise farmers' awareness of the importance of biosecurity. Farmers who receive training tend to be better able to implement effective biosecurity measures (Wahyuni *et al*., 2021). However, many smallholder farmers do not have access to this information and training, so the implementation of simple biosecurity measures is often overlooked.

Livestock health record keeping is an important part of biosecurity management. On large farms, records are kept systematically to monitor chicken health, vaccination and treatment. In contrast, on small farms, record-keeping is often not done, resulting in less effective disease surveillance (Zerssa *et al*., 2021). Another problem is the use of drugs without veterinary supervision, which has the potential to cause antibiotic resistance and worsen the health condition of livestock. Quarantine of incoming livestock or sick livestock is also an important part of biosecurity (Msimang *et al*., 2022). Large farms have generally implemented this step well, but in small farms, limited space and facilities are the main constraints. The lack of understanding about the importance of quarantine also hinders optimal implementation of this measure.

In general, the implementation of biosecurity in Penebel sub-district requires improvement, especially on small farms. This includes training and mentoring for smallholder farmers on simple yet effective biosecurity measures, provision of affordable facilities such as vaccines and sanitation tools, and development of a monitoring and evaluation system to ensure the sustainability of biosecurity implementation across all farm scales. By increasing the implementation of biosecurity, the risk of disease on chicken farms in Penebel Subdistrict can be minimized, which in turn can support the productivity and sustainability of the farm business (Wahyuni *et al*., 2021).

Highest Risk Mitigation Model for Chicken Farming Businesses

The highest risk mitigation model in chicken farming can be done by improving cage and environmental sanitation by keeping the cage clean, ensuring good ventilation, and changing the cage bedding regularly (Zerssa *et al*., 2021). Proper vaccination in the form of routine vaccination programs to prevent both zoonotic and non-zoonotic diseases. Farmer education in the form of training on livestock health management and disease prevention. Regular health monitoring in the form of routine examinations by veterinarians for early detection of diseases, as well as hygienic transportation arrangements for transporting chickens and checking the health of chickens before they are moved (Mc Mullin, 2022). By considering these risk mitigations, chicken farms in Penebel subdistrict can be better prepared for potential poultry health problems and reduce economic losses due to disease spread.

The highest risk mitigation model in chicken farming aims to reduce the negative impact of various potential risks that can interfere with animal health, productivity, and the sustainability of chicken farming (Ubom *et al*., 2023). The highest risks that often occur in chicken farming include the spread of disease, feed and water management, and poorly controlled environmental factors. Therefore, this risk mitigation model should include a comprehensive strategy that focuses on prevention, early detection and rapid response. The highest risk mitigation model in chicken farming includes disease prevention through biosecurity, routine vaccination, controlling the use of antibiotics, appropriate tools and resources (Ngom *et al*., 2024).

The most effective risk mitigation model in chicken farming encompasses comprehensive preventive strategies across multiple domains, including biosecurity, feed and water management, sanitation and environmental control, operational and financial management, as well as disease monitoring and early detection. By thoroughly implementing this model, poultry farmers can significantly reduce the risk of disease outbreaks, thereby safeguarding flock health and ensuring the long-term sustainability and profitability of their farming operations.

CONCLUSIONS AND RECOMMENDATIONS

The identification of poultry disease risk in Penebel Subdistrict is influenced by multiple factors, including environmental conditions, chicken health, farm management practices, external influences, hygiene and sanitation, socioeconomic status, and biosecurity measures. Analyzing the application and management of biosecurity on chicken farms in Penebel involves assessing the level of biosecurity implementation, management strategies, and evaluating their effectiveness. The most effective risk mitigation model in chicken farming incorporates comprehensive preventive measures across key areas such as biosecurity, feed and water management, sanitation and environmental control, operational and financial management, and disease monitoring with early detection. Proper and thorough implementation of this model can significantly reduce disease risks and promote the long-term sustainability of poultry farming in the region.

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NOVELTY STATEMENT

This study presents a novel risk mitigation model for poultry farming in Penebel District by analyzing disease prevalence, cage types, and biosecurity implementation. By integrating risk assessment with farm-level management strategies, this research advances localized disease prevention approaches, offering a scalable framework for enhancing poultry health and agribusiness sustainability.

AUTHOR'S CONTRIBUTIONS

Conceptualization, Gede Mekse Korri Arisena and I. Wayan Nico Fajar Gunawan; methodology, Romy Muhammad Dary Mufa and Dwi Putra Darmawan; validation, Ni Luh Made Indah Murdyani Dewi and Putu Devi Jayanti; investigation, Gede Wisnu Sahatmana and Keirrann Arthur Paskahadi; data curation, Putu Henrywaesa Sudipa; writing original draft preparation, Gabriel Adam Salombe.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflict of Interest

The authors declare no conflict of interest.

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