Research Article

Perceptions of Biosecurity Management among Swine Farmers in the Mekong Delta, Vietnam

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Abstract | Biosecurity plays a crucial role in preventing the transmission of disease globally. The study investigated the effect of the farmers' perceptions on biosecurity management (BM). A total of 240 smallholder farmers in Tra Vinh and Ben Tre were surveyed using a random sampling method. Descriptive statistics and multiple linear regression analyses were used to examine the data. The findings revealed that gender, income, perceived risk, perceived usefulness, and perceived cost significantly influenced biosecurity management. Among social factors, gender (B = -1.427, p = 0.024) was negatively associated with adopting biosecurity management, meanwhile income (B = 0.004, p = 0.022) was positively correlated with applying biosecurity management. In addition, farmers who perceived higher levels of risk (B = 0.619, p = 0.001), usefulness (B = 0.436, p = 0.024), and cost (B = 0.526, p = 0.009) were more likely to implement biosecurity management. By contrast, education level, main occupation, and farm size were not correlated with biosecurity management adoption. These findings emphasized the importance of considering farmers' social characteristics (gender, income) and perceptions (risk, usefulness, cost) toward improving the biosecurity management strategies for small swine farms. The findings of this study will help farmers and relevant stakeholders develop effective strategies to improve biosecurity management.

Keywords | Biosecurity management, Swine farm, Perception, Mekong delta, Social demographics, Smallholder farmer

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INTRODUCTION

Vietnam is among the leading pig-producing countries in Asia and globally. At the end of February 2024, the national swine population increased by 4.8% compared to the same period in 2023 (GSO, 2023). Despite this growth, the sector remains highly vulnerable to infectious diseases. In 2024, approximately 1.538 of African Swine Fever (ASF) were reported across 48 provinces and municipalities, resulting in the culling of over 88.258 pigs (FAO, 2024a). To prevent this issue, the implementation of biosecurity measures is essential for farmers. Biosecurity measures have been introduced to limit economic losses and zoonotic exposures to humans by preventing and controlling animal diseases (Msimang *et al.*, 2022). Previous studies showed that biosecurity practices significantly impacted the economic efficiency of livestock farms by helping livestock farms increase their economic efficiency, reducing the mortality rate of animals, and reducing the rate of abandonment of farms (Ha *et al.*, 2022).

In Vietnam, improving biosecurity has been identified by

the Vietnamese government as a critical measure to prevent future disease outbreaks. However, biosecurity practices need to required enhancements in swine farm. The study of Cuc *et al.* (2020) revealed that implementing biosecurity practices on swine farms in Vietnam has many challenges due to reasons such as management, geographic conditions, typical farm systems being small-household rather than larger-scale intensive systems, and limited knowledge of farmers. There are several factors influence the adoption of agricultural technology. According to Renault *et al.* (2021), the farmers were more likely to adopt biosecurity measures when they recognized their benefits and felt personally responsible for animal health. Social-demographic such as age, education level, and farm size play a crucial role in influencing decisions apply new technology (Michels *et al.*, 2021). Additionaly, Guntoro *et al.* (2024) also revealed that technology adoption was influenced by many factors, including perceived innovativeness, perceived usefulness, perceived ease of use, information/awareness, social influence, and perceived cost.

Therefore, further research is needed to understand the factors influencing biosecurity practices. In particular, gaining insight into farmers' perspectives on biosecurity and the reasons behind their views is crucial. This understanding can support the development of effective management strategies that promote both livelihoods and food security (Toson *et al.*, 2024).

Accordingly, the current study explored swine farmers' perceptions of biosecurity management in the Mekong Delta, Vietnam. Insights into how farmers understand and apply specific biosecurity measures are vital for designing practical and sustainable disease prevention and control strategies. These findings can also inform government policies aimed at enhancing biosecurity practices across the region.

MATERIALS AND METHODS

Location and time

The survey was conducted in Ben Tre and Tra Vinh provinces, which belong to the Mekong Delta region of Vietnam, where most farmers focused on swine farming activities, and were among the places seriously affected by the outbreak of ASF. The data was collected from January to June 2024. The two provinces are situated along a major transportation route to Ho Chi Minh City, the largest market in southern Vietnam, where animal movement is frequent and difficult to control. According to GSO (2023), the pig population in Ben Tre and Tra Vinh provinces is approximately 301,100 and 225,700, respectively. Therefore, these two provinces can be considered representative of swine production in the Mekong Delta.

Data collection

The survey was conducted in Vietnamese and employed purposive sampling, guided by information provided by government staff. Respondents were selected based on the following criteria: they owned at least 10 swine units, by Decree No. 13/2020/ND-CP (FAO, 2024b), and had a minimum of one year of experience in swine production. During the survey, all farmer data were kept secure, and appropriate measures were taken to ensure their privacy was protected. To ensure familiarity with biosecurity practices, only farmers who had received training on swine farm biosecurity regulations (QCVN 01-14:2010/BNNPTNT) were included. For number of respondents, in each province, three districts were selected, and from each district, 30 farmers were chosen. This sample size was based on the recommendation by Levine and Stephan (2022), who indicated that a minimum of 30 respondents is sufficient for statistical analysis when the population size is unknown. A total of 120 respondents were selected from each province to ensure a sufficient sample size. The questionnaire, divided into two sections, was distributed to these farmers to collect the necessary data.

- **Section 1:** This section presents the socio-demographic characteristics of the respondents, including age, gender, education level, primary occupation, income, and farm size, as summarized in Table 1.
- **Section 2:** This section focuses on biosecurity management practices at the farm level. The biosecurity management (BM) measures were categorized into four groups based on the framework by Carlos (1993): planning, implementation, control, and adjustment.
- **Section 3:** This section focused on famers survey about their perceptions of implementing BM. The respondent was asked to rate 10 statements related to the perception of risk, usefulness, and cost of applying the BM in their farm. The Likert scale was utilized in this section, which ranged from 1 (strongly disagree) to 5 (strongly agree) for each statement.

Data analysis

This data were analyzed by using IBM SPSS 26.0 (IBM Corp, Armonk, NY, USA), and statistical significance was determined at a 5% level. The social characteristics of farmers were evaluated by descriptive statistics, including min, max, mean, frequency and percent. For BM, each response received one point if the farmer agreed with the statement or implemented the corresponding practice, and zero if not. The total score was then used to assess the BM level of each swine farm (Kouam *et al.*, 2020). Regarding perception of farmers toward BM, a five-point Likert scale was used to measure perception of farmers toward biosecurity management, with scores ranging from a minimum of 10 to a maximum of 50. Notably, the results

Table 1: The definition of variables.

Variables	Definitions	Type of measurement
Independent variable		
Age	Farmer's age	Continuous
Gender	Farmer's gender	Dummy (1= Male, 0= Female)
Education	The level of farmers in the school	Category (1= primary school, 2= secondary school, 3= high school, 4= bachelor, 5= postgraduate)
Occupation	Whether the farmer's main occupation is animal husbandry	Dummy (0 = others; 1 = animal husbandry)
Experience	Number of years that farmers engage in raising swine	Continuous
Family labor	Number of members in the family	Continuous
Income	Money they get from rasing swine per month	Continuous
Farm size	Total lands that farmers used for rasing swine	Continuous
Perception	Perception of farmers towards BM	Likert scale
Dependent variable		
BM index	Composite score based on agreement with BM-related statements	Continuous

of the Cronbach's alpha analysis indicated a high level of reliability for each dimension measured, with reliability coefficients of 0.865 for perception of risk, 0.713 for perception of usefulness, and 0.896 for perception of cost.

Multiple linear regression was used to analyze the relationship between a single dependent variable and multiple independent variables. This method estimates the outcome of a dependent variable using the known values of independent variables. In this study, the dependent variables were farmers' biosecurity management practices. Statistical significance was determined at $p < 0.05$ or $p < 0.01$. The model is presented in the formulation as follow:

$$Y_{BM} = b_1x_1 + b_2x_2 + \ldots + b_nx_n + c. \text{ Here, } b_i\text{'s } (i=1,2\ldots n)$$

Where; Y_{BM} is the BM index is a dependent variable that is the total value of the BM on each farm. x is independent variables including x_1: Age, x_2: gender, x_3: education, x_4: main occupation, x_5: income, x_6: farm size, x_7: Perception risk toward BM, x_8: Perception usefulness toward BM, x_9: Perception cost toward BM.

RESULTS

Social profile characteristics and the status of biosecurity management of farmers in the Mekong delta

Table 2 showed that the social-dermographic of the surveyed farmers. Most farmers were male and belonged to an older age group, with the average age of 50.29. The level of education was high, with 69.2% graduating from high school. Most respodents (85.4%) stated that animal husbandry as their main occupation, highlighting a strong focus of farmers on livestock procuction. The average income reflected limited profitability that the average farm income was just 257.15 USD. Additionally, the average farm size was small, measuring only 0.18 hectares, which may constrain production capacity and income potential. For biosecurity management, farmers were more frequently practicing adjusting a biosecurity plan with the highest score (155/240 points) and implementing a biosecurity plan (152/240 points). In contrast, controlling and planning biosecurity was less of a concern (138 points and 122 points, respectively) (Figure 1).

Table 2: Social profile characteristics of small-scale swine farmers (n = 240).

Variables	Categories	Frequency	Percent (%)
Age (years)	Mean ± SD	50.29±7.40	
	Min	27	
	Max	65	
Gender	Female	36	15.0
	Male	204	85.0
Education	Primary school	14	5.8
	Secondary	58	24.2
	High school	166	69.2
	Undergraduate	2	0.8
	Graduate	0	0
Main occupation	Others	35	14.6
	Animal husbandry	205	85.4
Income (USD)	Mean ± SD	257.15± 132.73	
	Min	59.05	
	Max	787.40	
Farm size (ha)	Mean ± SD	0.18 ± 0.17	
	Min	0.01	
	Max	2.00	

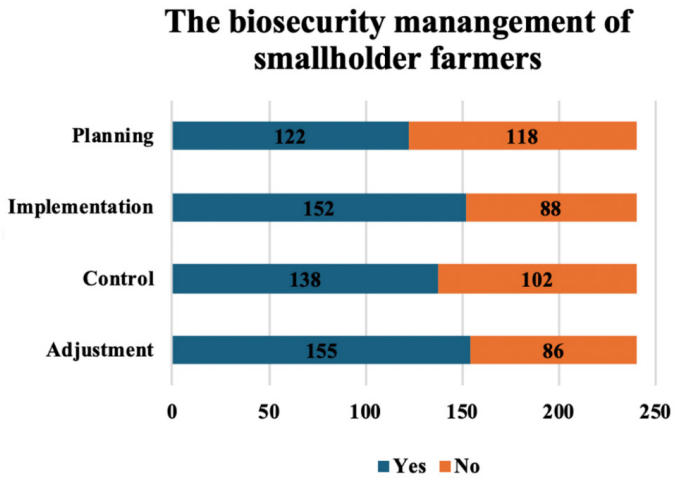

Figure 1: Biosecurity management of smallholder farmers.

The perception of farmers toward biosecurity management

The results (Table 3) pointed that famers perceived BM differently across three key dimensions: Risk, usefulness, and cost. In terms of perceived risk, the mean score of 3.25 ± 0.79 suggests a moderate level of concern. While nearly half (47.1%) of respondents agreed that BM requires high investment, and 42.5% believed it could lead to financial loss or wasted time, a majority (55.8%) found it difficult to maintain, indicating operational challenges. In contrast, perceptions of usefulness were more positive, with a higher mean score of 3.64 ± 0.42. Most farmers agreed or strongly agreed that BM helps in effective time and facility allocation (63.4%), helps reduce the risk of disease spread (57.9%), and offers clear guidance for implementation (67.0%). The findings indicated that farmers belived BM as a valuable and effective practice. Regarding cost perception, the average score was 3.30 ± 0.76. While more than half (58.8%) believed the costs of implementing BM were reasonable, maintenance requirements (45.4%) and uncertainty about net benefits (48.3%) remained concerns. Overall, the findings suggest that although farmers recognize the benefits of biosecurity management, financial constraints and perceived risks may pose barriers to adopt BM.

The result of Table 4 revealed that gender, income, perception of risk, perception of usefulness, and perception of cost impact adopting biosecurity management. In terms of the social characteristics, gender and income significantly influence BM practice, meanwhile, other characteristics did not effect on BM. The results showed that females tend to implement BM compared to males, with a negative effect of B = -1.427. Regarding positively affected BM, an increase in income (B = 0.004), perception risk (B = 0.619), perception usefulness (B = 0.436), and perception cost (B = 0.526) increased in applying BM. The equation could be written as follows: Y_{BM} = 6.874 + (-1.427 x gender) + (0.004 x income) + (0.619 x perception risk) + (0.436 x perception usefulness) + (0.526 x perception cost) with R^2 = 0.596.

Table 3: The perception of farmers toward biosecurity management.

Statements	Degree of perception				
	1	2	3	4	5
Perception risk					
BM is require high investments	5.8	30.4	15.9	47.1	0.8
BM can lead to economic losses and wasted time	5.8	33.3	15.9	42.5	2.5
BM is dificult to maintain	1.7	1.3	35.8	55.8	5.4
Mean ± SD	3.25 ± 0.79				
Perception usefulness					
A well-structured biosecurity management helps my farm to allocate facilities and time effectively in practicing biosecurity measures	0	0.4	36.2	57.1	6.3
BM help my farm to minimizethe risk of infectious diseases spreading	0.8	2.9	38.4	55.4	2.5
BM provide the necessary data and information to make exactly direction in implementing biosecurity measures	0	0	33.0	63.7	3.3
BM can help my farm to improve biosecurity measure	0.4	1.7	33.3	62.9	1.7
Mean ± SD	3.64 ± 0.42				
Perception cost					
BM cost for implementaton is not high	0	2.1	39.1	54.2	4.6
BM requires annual maintenance costs	4.6	30.4	17.9	45.4	1.7
BM provide more benefit than cost	4.5	21.3	23.8	48.3	2.1
Mean ± SD	3.30 ± 0.76				

Table 4: Effect of social profile characteristics on biosecurity management.

Criteria	Regression result				
	B	Std. Error	Beta	t	Sig.
Age	-0.008	0.030	-0.012	-0.281	0.779
Gender	-1.427*	0.629	-0.103	-2.268	0.024
Education	-0.361	0.423	-0.044	-0.852	0.395
Main occupation	0.429	0.625	0.031	0.686	0.493
Income	0.004*	0.002	0.117	2.300	0.022
Farm size	0.914	1.243	0.032	0.736	0.463
Perception of risk	0.619**	0.183	0.312	3.377	0.001
Perception of usefulness	0.436*	0.193	0.151	2.266	0.024
Perception of cost	0.526**	0.201	0.244	2.616	0.009
Constant	-5.658	3.043		-1.859	0.064

Note: Sig.: Significance level; B: Unstandardized coefficient; Beta: Standardized coefficient. $R^2 = 0.596$; $F = 37.742$; * $p < 0.05$; ** $p < 0.01$.

DISCUSSION

Most farmers were old people with an average age of over 50 years; the average age was higher than Dung (2022). It could be aligned with Uddin *et al.* (2016) pointed out that most of the young generation spent their time in the city and education. The gender and occupation aligned with previous research (Qui *et al.*, 2024). Males tend to focus on agricultural activities than females, and swine production is dominant in their jobs. Besides, the level of education is slightly higher, with most farmers finishing high school. It could influence the adoption of biosecurity management on their farm. Education and training enhance the ability of farmer and willingness to make successful changes to their management practice (Kilpatrick, 2000). In this study, the income of farmers was still at a medium level. According to Dung (2022), income plays an important role in adopting agricultural practices.

The results of BM practice revealed that farmers had a well-structured biosecurity management with full of four functions (planning, implementing, controlling, and adjustment). The results aligned with Tovmasyan (2017), management is the whole process of management functions such as planning, organizing, motivating, and controlling, which is performed to accomplish the main objectives of the organization by the use of people and other resources. The findings confirmed that most farmers prefer implementing and adjusting rather than having a biosecurity plan and controlling their prevention activities. More than half of farmers focus on planning biosecurity. It is essential to have a biosecurity plan for performing biosecurity on farms, reducing disease outbreaks and their spread. Previous studies showed that a comprehensive biosecurity plan should include the identification of potential hazards, implementation of risk reduction strategies, clear assignment of responsibilities, and systematic record-keeping of actions taken (Pietrak and Walsh, 2010). An effective biosecurity plan enhances preparedness by enabling farms to respond proactively to changing conditions (Anđelić *et al.*, 2017). A previous study of Edmondson *et al.* (2001) emphasized that setting aside time for reflection or debriefing before, during, and after implementation supports continuous improvement. Similarly, Stanković *et al.* (2016) highlight the importance of regularly reassessing biosecurity plans to ensure their continued effectiveness in preventing disease. In addition, Dědečková (2020) underscores the role of control as a vital organizational function. It helps identify gaps between planned actions and actual outcomes, facilitates corrective measures, and supports informed decision-making.

Regarding the perception of farmers toward BM showed that most respondents are highly aware of the benefits of implementing BM. The farmers highlighted that BM helped they allocate facilities and time effectively in practicing biosecurity measures. Management can help farmers identify the resources needed and optimize the use of those resources in implementing biosecurity measures. Indeed, management activities included functions such as planning, organizing, motivating, and controlling, which help managers use resources to achieve the set goals (Tovmasyan, 2017). According to Lubis *et al.* (2019), management is an important activity in any field of work, large or small. In which, resource management plays an important role in being able to produce appropriately. Properly managed resources will help reduce waste. At the same time, resource optimization is essential for production growth. Furthermore, the addoption of modern agricultural technologies was a promising strategy to improve agricultural productivity in improving agricultural productivity. This study also pointed out that there are many factors affecting biosecurity management, consist of social factors (gender, income) and perception (risk, usefulness, cost). According to Qui *et al.* (2024) stated that these social traits affect the perception of farmers on preventing measures, animal health, management techniques, and decision-making.

Gender was found to have a negative effect, indicating that female farmers were more likely than male farmers to engage in BM. Today, both women and men have equal opportunities to participate in BM practices. Women continue to play a vital role in agriculture, contributing to a wide range of activities. Malo (2020) noted that women have made significant contributions to inclusive agricultural development through their involvement in crop production, horticulture, livestock management, poultry, aquaculture, and natural resource management.

While previous studies suggest that investing in female farmers can yield substantial benefits, the economic returns of empowering women in agriculture are still under-researched (Anderson *et al*., 2021).

Regarding income, this factor positively influenced the BM. The results of the study are similar to those of Amalraj *et al*. (2024) and Wang *et al*. (2023), farm income is one of the main factors influencing the application of biosecurity. Indeed, financial factors play a very important role in implementing biosecurity-related activities. According to Buckel *et al*. (2024), small-scale chicken farmers in Ghana face many financial difficulties despite their awareness of the importance of biosecurity.

Additionally, the study found that some social factors did not have a significant association with BM such as age, education level, occupation and farm size. The finding align with Kouam and Moussala (2018) that farmer's age, gender, education level, and herd size did not affect the level of biosecurity. Similarly, Lestari *et al*. (2021) noted that household size had no significant regression coefficient in relation to biosecurity practices on beef cattle farms in Bone Regency. According to Hoang and Anh (2024) also revealed that no significant correlations between variables such as age, occupation, education, labor, family size, feeding practices, and farmers' knowledge or perceptions regarding the prevention of highly pathogenic avian influenza. However, this results was in contrast with study by Lestari *et al*. (2019), who stated that education level significantly influenced the adoption of biosecurity measures in beef cattle farms ($P < 0.01$). Most farmers in this research were above 50 years and not relate to their aplying in preventing practice. This finding does not align with the results of Ngoshe *et al*. (2022), who found that older farmers demonstrated greater knowledge of animal diseases and adopted more effective practices for the prevention and management of zoonotic diseases compared to their younger counterparts. These factors did not significantly influence preventive practices, possibly because other factors such as the personal background, past experience, access to information, social environment, and subjective interpretation of individuals (Hinjoy *et al*., 2023), as well as emotional states and normative beliefs (Doidge *et al*., 2021), could stronger influence on farmers knowledge and perception.

In addition, all of perception factors influence the application of BM. The perceptions of risks, benefits, and prices have a positive influence on BM. These findings highlight the critical role of psychosocial factors such as awareness in shaping behavior and decision-making at the farm level. The results of the study are similar to previous research (Stefania *et al*., 2024), which pointed out that some factors are barriers to the implementation of biosecurity measures by farmers, such as management, psychosocial factors, and economics. According to Tovmasyan (2017), management activities are shaped by the mental processes of an individual and are influenced by various factors, including the role of the manager, level of expertise, leadership, decision-making and communication skills, as well as personality traits, temperament, and psychological characteristics.

Furthermore, the effectiveness of management and decision-making is influenced by several factors, including the psychological characteristics of managers. Perceptions of implementation costs also play a significant role, with positive perceptions encouraging the adoption of biosecurity measures. Lestari *et al*. (2022) identified key barriers to implementing biosecurity practices, including limited knowledge, time constraints, and high costs. According to the study of Qui *et al*. (2024), who stated that one of the barriers affecting the application of disease prevention and treatment measures is financial problems.

Additionally, there was an increased perception of benefits leading to an increase in BM practice. Indeed, when farmers were aware of a new technology, they tended to apply that technology on their farms. According to Renault *et al*. (2021), the adoption of biosecurity-related activities is significantly influenced by the perception of farmers regarding the benefits of the measures and the perception of health responsibility. The perception of benefits helped farmers to implement BM more, and it helped improve economic efficiency, reduce mortality and farm abandonment rates (Ha *et al*., 2022). The farmers tended to apply a technology when they had enough perception of these benefits. This finding is consistent with previous studies by Admassie and Ayele (2011), which noted that farmers recognized the economic viability of adopting new technologies before considering the potential benefits of increased usage.

CONCLUSTION

This study provides important understangding of the demographic and psychological factors influencing biosecurity management among swine farmers. The majority participants were male, over the age of 50, and relatively well-educated, with swine production serving as their primary livelihood. Within biosecurity management, implementation and adjustment activities were more frequently practiced than planning and control. Besides, the finding pointed out that significant associations between biosecurity management and factors such as gender, income and the perception of farmers regarding risk, usefulness and cost. Female farmers were more likely to adopt

biosecurity management than male, indicating a potential gender-based difference in agricultural management activities. Notably, higher income and stronger perceptions of the value and necessity of biosecurity management were positively linked to greater adoption of such practices. These findings highlight the importance of addressing both socio-economic and perceptual barriers to improve the effectiveness and uptake of biosecurity interventions in the livestock sector.

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NOVELTY STATEMENT

This study highlights the significant role of farmers' perceptions and socio-economic factors in shaping biosecurity management adoption among smallholder swine farms in Vietnam. It reveals that perceived cost can positively influence adoption, while traditional factors such as education and farm size are not significant. These findings provide a more behavior-focused perspective for improving biosecurity strategies.

AUTHOR'S CONTRIBUTION

NTAT, BG and ARSP designed the experiment. NTAT, CCD, NHQ and NTL collected and analyzed data. NTAT, NHQ, NL, NTL interpreted data and drafted the manuscript. NTAT, BG, ARSP and NHQ edited the manuscript. All authors carefully read and approved the manuscript for publication.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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