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The Factors Influence the Biosecurity Management of Swine Farm in Mekong Delta, Vietnam

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Globally, biosecurity is one of the important methods to improve farm prevention under disease transmission. The study involved 240 swine farmers in Long An and Ben Tre provinces to determine social demographic characteristics and biosecurity management status and analyze the effects of social demographics on biosecurity management, including planning, implementation, controlling, and adjustment, which were collected by a random sampling method. A descriptive statistic and multiple linear regression analysis were employed to analyze the data. The results found that most respondents were male (70.4%), with an average age of 49.28 years old, with 38.3% finished undergraduate education, a mean experience of 14.48 years, having more than 4 members in the family and more than one labor take part in farming activities. Farmers were more likely to implement and adjust the biosecurity plan, while they were less focused on planning and controlling their biosecurity management. Our results found that the highest proportion was an adjustment, accounting for 75.52%, while the lowest was the controlling (61.92%), especially since farmers did not evaluate their biosecurity activities frequently. Besides, an increase in education, occupation, family members, and labor could increase 1.252, 2.627, 0.859, and 1.156 times, respectively, in biosecurity management, while age was found to have a negative impact. In conclusion, these findings emphasized the importance of considering sociodemographic characteristics when developing and implementing biosecurity strategies for small swine farms.
Keywords: Biosecurity management, swine farm, smallholder, Mekong delta, social demographics, smallholder farmer.

INTRODUCTION

The swine farming industry is one of the developed sectors in Vietnam. According to GSO (2023), the number of swine in early 2023 increased by 10.4% compared to last year. Despite being a global leader in swine farming, the country has faced challenges in controlling the spread of highly contagious diseases. In February 2019, the first outbreak of African Swine Fever (ASF) in Vietnam was reported from Hung Yen province (Le *et al.*, 2019). Since then, cases of ASF have been widely spread throughout the entire country, with approximately 6 million swine culled from 2019 to 2020 (Lee *et al.*, 2021). Additionally, the outbreak of contagious diseases such as highly pathogenic avian influenza in poultry (Islam *et al.*, 2024) and classical swine fever in swine (Ukita *et al.*, 2024) was due to the failure of farm biosecurity practices. Therefore, biosecurity was considered for the prevention of swine disease in Vietnam. Many benefits in the application of biosecurity reduce the risk of disease introduction and dissemination (Islam *et al.*, 2023). Implementing biosecurity management (BM) is a powerful tool for controlling farm diseases (Kouam *et al.*, 2020). Similarlly, Jiang *et al.* (2022) emphasized that biosecurity remains the most effective strategy for preventing and controlling outbreaks of ASF. However, Lee *et al.* (2021) argued that poor biosecurity in smallholder farms was the main contributing factor to the rapid spread across the country over a short period, resulting in huge economic losses for the swine industry. In Vietnam, smallholder swine farms account for the high percentage that is reputed to have low biosecurity levels, and barriers to good biosecurity continue to exist, especially for traditional smallholder farms; it could be due to

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insufficient finances to invest in biosecurity facilities (Nguyen-Thi *et al.*, 2021). According to Cuc *et al.* (2020), there are many reasons for the difficulties in implementing biosecurity, such as management, geographical conditions, small-scale farming systems, and limited knowledge of farmers. According to the research of Lestari *et al.* (2022), the primary barriers to biosecurity adoption were a lack of knowledge (64.35%), insufficient time (20.87%), and high cost (14.78%). Mutua and Dione. (2021) reveal a lack of adherence to biosecurity measures, even to the most basic biosecurity practices, especially for farmers and other actors in the pig value chain. Young *et al.* (2015) suggest that empowering farmers to make informed decisions and aligning biosecurity practices with their motivations can increase adoption rates. By applying change management principles, it may be possible to improve regional biosecurity efforts and enhance the control and eradication of transboundary diseases in the Mekong region. Furthermore, previous research suggests that socioeconomic factors, such as gender, education, and income, significantly influence farmers' adoption of biosecurity practices (Beharielal *et al.*, 2022; Oliveira *et al.*, 2018; Ritter *et al.*, 2017). These factors can impact farmers' perceptions of risk, their willingness to invest in preventive measures, and their ability to implement effective biosecurity protocols (Qui *et al.*, 2024; Mbanda-Obura *et al.*, 2017).

In addition, previous studies have only focused on biosecurity practices rather than biosecurity management. Therefore, it is necessary to identify factors that can influence biosecurity management in swine smallholder farmers in the Mekong Delta. This research focuses on swine smallholders in the Mekong Delta, in which most smallholders earn income for living. Thus, the study investigates the status of biosecurity management and the relationship between social characteristics and biosecurity management on smallholder swine farms. The understanding of biosecurity management from this study would help to find a solution to enhance biosecurity management and provide necessary actions to prevent and control disease efficiently. The aim of study focus on smallholder farmer who have some strugle in apply biosecurity. This study will contribute to the body of knowledge relevant to biosecurity management. These findings may be useful to the government policies in that they should consider the results of the study can help them improve their policy biosecurity management for the farmers in the Mekong Delta.

MATERIALS AND METHODS

Research location: The survey was conducted in Ben Tre and Long An provinces belonging to the Mekong Delta, Vietnam, where most farmers focused on swine farming activities and is one of the places seriously affected by ASF. These districts were chosen because the number of swine in the two provinces was significantly high and could be representative of swine production in the Mekong Delta. Besides, the two provinces are located on the main traffic route to Ho Chi Minh City - the biggest market in southern Vietnam, and the movement of animals is dynamic and difficult to control.

Data collection: The survey was conducted from January to May 2024 to get data in Vietnamese language. A purposive sampling method was used to select samples from the total of small swine farmers by following information from the government staff. The sampling was chosen as follows: farmers had to own at least 10 swine units on their farm (according to Decree No.13/2020/ND-CP of Vietnam (FAO, 2024) and have experience of at least 1 year in swine production. Besides, to ensure the farmer know biosecurity, we choose the respondents who had training about regulation conditions for biosecurity of swine farms (according to QCVN 01-14:2010/BNNPTNT). The criteria were performed to ensure that the respondents were representative. Besides, the respondents were chosen by following the formulation of Tabachnick and Fidell (1996) as below:

$$N = 50 + 8*n$$

Where: N was the number of respondents in the study, and n was the study's independent variable. This study included 7 independent variables: age, gender, education level, occupation, experience, family member, and labor. It was clear that 106 respondents were selected in each province,

Table 1. The definition of variables.

Variables	Definitions	Type of measurement
Independent variable		
Age	Age of the farmers in the year	Continuous
Gender	Gender of respondent	Dummy (1= Male, 0= Female)
Education	The education of farmers in the school	Categorical (1 = primary school, 2 = secondary school, 3 = high school, 4 = bachelor, 5 = postgraduate)
Occupation	The main occupation of farmers	Dummy (0 = others; 1 = animal husbandry)
Experience	The number of years of farmers in rasing swine	Continuous
Family member	The number of members in the family	Continuous
Labor	The number of worker	Continuous
Dependent variable		
BM index$_i$	The scores that farmers agreed with statement for biosecurity management	Continuous

according to the above formulation. However, to ensure a valid number of respondents, we chose 120 respondents per province for this study. The questionnaire will be sent to farmers to collect data and divided into 2 sections below:

***Section 1*:** the respondents were asked about their personal information, including age, gender, main occupation, formal education, number of family members in the household, and labor, which are described in Table 1.

***Section 2*:** Information on farm BM was recorded. According to Carlos (1993), management has four components: planning, implementation, control, and adjustment. The measure of BM will be collected in four categories, including planning, implementation, control, and adjustment; a total of 19 subcategories are shown in Table 3

***Data analysis*:** This study examined farmers-related social information and its impact on farm biosecurity management. For BM, each answer in four categories is given 1 point if the respondent agrees with the statement or does the action at the farm and 0 points if they do not; scores were subsequently summed to determine the BM of a swine farming household (Kouam *et al.*, 2020). Each statement was calculated by dividing the total number of agreed farms by the total number of farms; the ratio was expressed as a percentage.

Data were analyzed using IBM SPSS 26.0 (IBM Corp, Armonk, NY, USA), and statistical significance was determined at a 5% level. Descriptive statistics were used to analyze these social characteristics, including frequency and mean. Multiple logistic regression analysis was used to evaluate the relationship between the farm biosecurity management index and social profiles. A regression model was formulated as follows:

BM index_i = b1x1 + b2x2+ … + bnxn + c ($i=1,2…n$)

Where, BM index is a dependent variable that is the total value of the BM on each farm.

x is the independent variable of social demographic characteristics, including x1: Age, x2: Gender, x3: Education, x4: Occupation, x5: Experience, x6: Family member, and x7: Labor. The results were expected that an increase in dependent variables of x1-x7 significantly increases/degree BM of the farm.

RESULTS

***Social profiles of farm characteristics*:** Table 2 shows that most respondents (70.4%) were male, highlighting that male played an important role in raising swine. Second, the survey discovered that the average age of the farmers was 49 years, with over 14 years of experience in swine farming. Nearly two-thirds of the respondents were focused on swine farming and had high levels of education, particularly having completed high school or a bachelor's degree (38.3% and 37.5%, respectively). The average family member was high, with 4 members per household and more than one laborer participating in their swine production.

Table 2. Social profiles characteristics of small-scale swine farmers (N = 240).

Variables	Categories	N	Result
Age	Mean ± SD		49.28 ± 8.744
	Min		27
	Max		67
Gender (%)	Female	71	29.6
	Male	169	70.4
Education (%)	Primary school	0	-
	Secondary	31	12.9
	High school	90	37.5
	Undergraduate	92	38.3
	Graduate	27	11.3
Main occupation (%)	Others	67	27.9
	Animal husbandry	173	72.1
Experience	Mean ± SD		14.48 ± 7.52
	Min		2
	Max		37
Family member	Mean ± SD		4.36 ± 1.05
	Min		3
	Max		9
Labor	Mean ± SD		1.40 ± 0.66
	Min		0
	Max		4

***Status of biosecurity management*:** Overall, the study found that farmers were generally masters in performing biosecurity adjustment with 75.52%, and the second performance was implementing a biosecurity plan (71.56%). In contrast, the respondents were less concerned about controlling biosecurity and planning (61.92% and 64.79%, respectively). As for biosecurity planning, farmers were most likely to identify their potential source for biosecurity practice with 90.83% (218/240). On the other hand, guidance for recording when finishing biosecurity practices was less prevalent (45%). For the implementation of the biosecurity plan, 80.83% of respondents purchased the tools and equipment for applying biosecurity practices, while arranging the person for practice was less emphasized. The finding also confirms that farmers rarely consult biosecurity with experts or veterinary staff. Notably, self-monitoring biosecurity practices are engaged by almost all farmers (80%). In terms of biosecurity adjustment, most farmers adjust their biosecurity practices, with 75.52% of respondents agreeing. However, farmers are more likely to self-adjust their biosecurity practices compared to consult with veterinary officials.

***The effect of social profiles on biosecurity management*:** The results of Table 4 demonstrated that several sociodemographic factors influence applying biosecurity management, such as age, education, occupation, family members, and labor. An increase in education, occupation, family members, and labor increased by 1.252, 2.627, 0.859, and 1.156 times, respectively, of the biosecurity management index, and all other factors were kept constant. In contrast, age negatively affected BM (B = - 0.091, p = 0.03); young farmers prefer to implement biosecurity measures compared

Table 3. The result of the biosecurity management evaluation.

Category	Subcategory	N	Practice percentage
Planning	Identifying the quantity and quality of available resources for biosecurity in swine farms	218	90.83
	The plan should determine the specific time and establish goals for biosecurity practice	133	55.43
	Define who is responsible for each action in biosecurity practice	147	61.25
	Listing the steps taken biosecurity practice	154	64.17
	The guidance for recording when the biosecurity measure finish	108	45.00
	Regular review and adjustment of strategic plans when farmer got new in	173	72.08
	Mean ± SD		64.79 ± 15.65
Implementation	Investigate tools and equipment for practice biosecurity	194	80.83
	Arrange personnel for practicing biosecurity	154	64.17
	Disseminate the biosecurity plan to members	165	68.75
	Coordinate the implementation of biosecurity measures	174	72.50
	Mean ± SD		71.56 ± 7.06
Control	Monitoring results weekly and monthly	203	84.58
	Recording information relate to biosecurity practice	124	51.67
	Comparing results to a standard of biosecurity	137	57.08
	Regularly evaluate biosecurity activities by experts or veterinary officer	88	36.67
	Analyzing the results to identify problems and take corrective action	191	79.58
	Mean ± SD		61.92 ± 19.95
Adjustment	Reconsidered the biosecurity plan after each production cycle	184	76.67
	Consult with a specialist or veterinarian to adjust the plan	151	62.92
	Self-adjust biosecurity to a particular condition and requirements	200	83.33
	Investing new equipment and new methods to perform biosecurity practice	190	79.17
	Mean ± SD		75.52 ± 8.84

to old farmers. Gender and experience did not significantly correlate with biosecurity management ($p > 0.05$). The equation could be written as follows: $Y = 6.874 + (-0.091 \times age) + (1.252 \times education) + (2.627 \times occupation) + (0.859 \times family\ member) + (1.156 \times labor)$.

Table 4. The effect of social profiles on biosecurity management.

Variables	Regression				
	B	Std. Error	Beta	t	Sig.
Age	-0.091*	0.042	-0.158	-2.186	0.030
Gender	-1.317	0.672	-0.119	-1.961	0.051
Education	1.252**	0.384	0.212	3.260	0.001
Occupation	2.627**	0.672	0.233	3.912	0.000
Experience	0.074	0.048	0.110	1.536	0.126
Family member	0.859**	0.287	0.177	2.987	0.003
Labor	1.156*	0.472	0.152	2.449	0.015

Noted: sig.: significant; * significant at $p < 0.05$; **, significant at $p < 0.01$. $R^2 = 0.200$, $F = 8.264$, Sig = 0.000

DISCUSSION

The results of the social profile were suitable to the previous research (Qui *et al.*, 2020; Guntoro *et al.*, 2023; Qui *et al.*, 2024). Guntoro *et al.* (2023) emphasized the importance of carefully examining social profiles before going to the perception of farmers. Ritter *et al.* (2017) further highlighted that each farmer has a unique combination of factors influencing their agricultural practices. These factors include demographics, experiences, personality, routines, goals, and cultural, economic, and familial influences. Understanding these individual differences is crucial for developing effective agricultural interventions and supporting farmers in their decision-making processes. The results are similar to the study of Kouam *et al.* (2018), in which most farm owners were male. In addition, the average age of farmers was 49 years old; the results were similar to the survey of Qui *et al.* (2024). Young people prioritize schooling; they may have less time to participate in animal farming activities. That is why old farmers mostly joined in swine farm operations.

The findings confirmed that most farms had a well-structured biosecurity plan. The structure is consistent with the research of Pietrak *et al.* (2010), who recorded a comprehensive biosecurity plan that should include identifying potential hazards, implementing risk mitigation strategies, assigning responsibilities, and maintaining records of completed actions. It is essential to have a biosecurity plan for performing biosecurity on farms, reducing disease outbreaks and spreads. Reviewing and updating the biosecurity plan somehow increases biosecurity practice. It is also indicated in the study of Stanković (2015) that they regularly reassess plans to ensure their effectiveness in keeping the farm free from diseases. However, the guidelines for biosecurity practice in this study are less emphasized.

Most farmers often focus on biosecurity implementation rather than planning or monitoring their disease prevention. As recorded in the study of (Cuc *et al.*, 2020; Scollo *et al.*, 2024; Anh *et al.*, 2023), biosecurity implementation is performed by most farms. Notably, farmers emphasized the investigation of tools and equipment to support biosecurity implementation. Investing in tools and equipment is important in implementing biosecurity measures. According to Kim *et al.* (2017), the main risk of transmitting the porcine epidemic is from the boots and protective clothing of employees that are contaminated with large amounts of the virus. Thus, one of the necessary investments is handwashing, boots, and protective clothing

Additionally, the arranged person for performing the biosecurity was less attention. The respondents in this study were smallholder farmers who often did not assign stable jobs to specific individuals. They could flexibly transfer jobs to each other to implement biosecurity. According to Layton *et al.* (2017), biosecurity evaluations can also enhance risk management at both farm and regional levels. Our result argued that the respondents were less likely to seek veterinary staff to evaluate or adjust their biosecurity practices. This finding aligns with previous research by Sayers *et al.* (2014), which found that a lack of regular connection between farmers and veterinarians can lead to a shortage of standardized veterinary information; the farmers did not pay attention to connecting with veterinary staff to perform biosecurity. Can *et al.* (2020) also stated that to ensure the success of national biosecurity programs, farmers need to collaborate with various stakeholders, including policymakers, breeding organizations, industry representatives, researchers, and veterinarians. Research by Klein *et al.* (2023) indicated that veterinary officials and farm veterinarians play a crucial in referencing the topic of biosecurity.

This study also noted that many social factors influence BM adoption, such as age, family members, labor, education, and occupation. In terms of age, young farmers prefer participating in BM to the elder generation. Biosecurity management requires flexibility and adaptability to changing disease and farm conditions. However, adaptability to changing conditions for the livestock industry is not strongly dependent on age. It was similar to the study of Brown *et al.* (2019); older farmers tend to avoid risks and are less willing to try new methods or technologies; it is partly due to the family's traditional and traditional biosecurity practices. Besides, younger farmers or less experienced farmers tend to adopt new measures and technologies to ensure the production performance and livestock health of their farms. It was also indicated in the study of Yang *et al.* (2020) that age could affect the technology acceptance and apply a new production practice for their farm. For labor, this study found that the farmers were more likely to engage BM if they had more family members and labor. In the study by Can *et al.* (2020), the population employed in agriculture positively affected the biosecurity levels. As previously mentioned, farmers with larger families and more labor are more likely to implement biosecurity practices (Gao *et al.*, 2017). This may be attributed to the increased manpower available for vaccination, cleaning, and disinfection tasks. Additionally, a larger family can provide a more stable workforce, reducing reliance on external labor and minimizing the risk of disease introduction. Research by Qui *et al.* (2024) found that farmers with additional support were more likely to manage their farming activities and prioritize disease prevention efficiently.

Education is one of the factors that impact the success of BM. The results are partially coherent with Ajewole and Akinwumi (2014), who reported that the level of education of farmers has a significant positive influence on livestock farms' biosecurity. Similarly, Can and Altuğ (2014) found that herd size and producers' education level were positively correlated with biosecurity scores on dairy cattle farms. Can *et al.* (2020) demonstrated a strong correlation between education level and income with biosecurity scores; the results also indicated that the increase in farmer education is more likely to adopt biosecurity management. Previous research has highlighted a significant knowledge gap among farmers regarding biosecurity management. This lack of understanding poses a substantial challenge to the adoption of effective practices in livestock production. Pritchard *et al.* (2015) declared that insufficient knowledge is a primary barrier to implementing negligent biosecurity practices in cattle farming. Farmers with higher levels of education are more likely to be aware of disease prevention strategies and to have the knowledge and skills necessary to implement them effectively (Guntoro *et al.*, 2023; Seid *et al.*, 2020).

At the same time, gender and experience had no significant effects on BM. According to Duong *et al.* (2019), perceptions of biosecurity threats did not have a relationship with gender and age. Similarly, the study of (Can *et al.*, 2020) also recorded no effect of gender on biosecurity practices. For gender, females and males have an equal opportunity to participate in the practice of biosecurity management. Nowadays, women's duty is also to perform agricultural tasks and keep going to play a critical role. It may indicate that women are better at agriculture tasks that require meticulousness and accuracy. It is also indicated in the study of (Rahutami and Matitaputty, 2017; Antriyandarti *et al.*, 2024) that women play an important role in most agricultural activities and have great responsibility in these activities. Besides, women put in more effort and longer working hours than men. In the study of (Satyavathi *et al.*, 2010), women are recorded as contributing to food production and rural livelihoods. Furthermore, the experience did not influence BM. It aligns with the results of Whelan *et al.* (2021), revealing no significant results in connecting past experiences with prevention or biosecurity practices.

***Conclusion*:** The study indicates that the majority of participants were male, over 49 years old, and had a high level of education. Most farmers focus on swine production as their main occupation. Within biosecurity management, implementations and adjustments are more likely to be practiced than planning and controlling. There are several factors that are correlated with BM, including age, education, occupation, family members, and labor. Notably, an increase in education, occupation, family size, and labor were positively affected by the implementation of BM, and young farmers tend to perform BM compared to old farmers.

***Authors' contributions*:** N.T.A. Thu, B. Guntoro, A.R.S. Putra designed the study; N.T.A. Thu, N. H. Qui implemented the survey and collected data; N.H. Qui, B. Guntoro, A.R.S. Putra, N.T.A. Thu, N. Liangco, C.C. Dang prepared the draft; B. Guntoro, A.R.S. Putra reviewed and finalized the manuscript.

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