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Exploring the Factors Influencing Shrimp Farmers' Adoption Intentions toward Improved Disease-Prevention Technologies

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ABSTRACT

Shrimp production is adversely affected by diseases, particularly in giant tiger prawn and whiteleg shrimp. The predominant use of inexpensive antibiotics by shrimp farmers has resulted in antibiotic overuse and antimicrobial resistance (AMR) at the farm level. However, the adoption of new antibiotic-related technologies remains low due to their high cost and farmers' reluctance. This study explored key factors influencing shrimp farmers' intentions to adopt improved disease-prevention technologies. Stratified random sampling selected 123 shrimp farmers from four regions in Peninsular Malaysia, and data were collected through a structured questionnaire. Several statistical analyses were employed to scrutinize the collected data, encompassing descriptive analysis, Chi-square analysis, factor analysis, and logistic regression analysis. The research findings revealed a significantly high intention (74.0%, n=91) among shrimp farmers toward adopting improved disease-prevention technologies. The analysis unveiled a significant correlation between attitude (ß=2.062, p<0.000) and the intention of shrimp farmers toward adopting improved disease-prevention technologies in their shrimp farming practices. Notably, those with a positive attitude were found to be 7.9 times more interested in adapting these technologies, underlining attitude as the predominant influence in this context. These findings offer valuable insights to enhance the competitiveness of the aquaculture sector in shrimp production and animal health advancements. Promoting sustainable and responsible practices has become the key to ensuring the shrimp farming sector's long-term success and resilience.

Keywords: Attitude; Disease-prevention technologies; Shrimp farmers intentions; Shrimp farming

INTRODUCTION

Aquaculture stands as one of the most sustainable sources of protein and the fastest-expanding food sector globally. Nevertheless, meeting the rising global food demand requires a 50% increase in production by 2050 (Food and Agriculture Organization, 2014; Thornber et al., 2020). Aquaculture has gained acknowledgment as the primary strategy to bridge the global gap between consumer demand and fish supply. Marine prawn farming, predominantly centered around whiteleg shrimp (*Penaeus vannamei*) and giant tiger prawn (*Penaeus monodon*), stands out as the main contributor to this output. It is highlighted in previous research by Anirudhan, Tosin, Wahid, and Sung (2021) and Nurhafizah et al. (2021).

Understanding the significance of aquaculture as a crucial food and nutrition source becomes paramount, considering factors such as population growth, increasing affluence, surging demand for animal protein, and evolving consumer preferences (Samah, 2020; Sampantamit et al., 2020). With changing consumer tastes and preferences, the demand for aquaculture products, particularly shrimp, has soared both domestically and worldwide. Unfortunately, shrimp production in Malaysia has seen a decline over the past four years, dropping from 61,386.35 tonnes in 2014 to 45,912.87 tonnes in 2018, according to the Annual Fisheries Statistics (2010-2020) by the Department of Fisheries Malaysia (Department of Fisheries Malaysia, 2020). This decline has been attributed to various challenges, including the high cost of manufacturing due to resource scarcity and inadequate supply of inputs (Samah, 2020).

Disease poses a significant challenge in aquaculture, particularly threatening the sustainable development and long-term viability of shrimp and prawn farming, leading to substantial economic consequences for large areas of the industry (Samah, 2020; Thornber et al., 2020). Shrimps are highly susceptible to various bacterial, viral, fungal, and parasitic infections. Among these, viral and bacterial disease outbreaks have received considerable attention and inflicted severe financial losses on aquaculture farmers (Anirudhan et al., 2021; El-Saadony et al., 2022). In recent times, bacterial infections have rapidly spread across several Southeast Asian nations. For example, Vietnam experienced an outbreak in 2010, followed by Malaysia in 2011, Thailand in 2012, the Philippines in 2013, and even the American continent, affecting Mexico in 2013 (de la Peña et al., 2015; Thiang et al., 2021). The widespread nature of these infections underscores the urgency of addressing disease management strategies in aquaculture.

The rise in disease incidences within the aquaculture sector has led to the widespread use of veterinary antibiotics, both directly and indirectly, through feed to treat parasite disorders, prevent bacterial infections, and promote growth (Chen, Ying, & Deng, 2019; Nurhafizah et al., 2021). Commonly employed antibiotics in aquaculture production, such as tetracyclines, sulfonamides, oxolinic acid, sulfamerazine, and erythromycin, have been approved by the Association of Southeast Asian Nations (ASEAN) (Nurhafizah et al., 2021; Thiang et al., 2021). However, farmers' indiscriminate overuse of antibiotics as growth promoters and prophylactic treatments, driven by the desire to combat diseases and enhance profits, raises concerns over the emergence of multidrug-resistant bacteria in the environment, posing significant health risks (Imron, Kurniawan, & Abdullah, 2021; Kurniawan et al., 2021). Unfortunately, the lack of antimicrobial usage laws, governmental oversight, and monitoring infrastructure remains a pressing issue in the majority of shrimp farms across Southeast Asian countries (Chuah, Effarizah, Goni, & Rusul, 2016; Thiang et al., 2021). Hence, addressing these challenges becomes essential to ensure sustainable and responsible aquaculture practices.

Antibiotics are commonly administered to aquaculture through feed or water, leading to potential seepage into the ecosystem via water runoff, excrement sedimentation, or uneaten feed pellets, which nearby fish or invertebrates may consume (Fauzi et al., 2021; Muziasari et al., 2017). Unfortunately, aquaculture discharge stands as a major contributor to antibiotic contamination in the environment due to inadequate waste disposal infrastructure. As a prevailing practice, aquaculture waste is often directly discharged into nearby rivers or lakes, exacerbating the issue (Kurniawan et al., 2021; Thiang et al., 2021). The presence of antibiotic residues in the environment can have harmful effects on human health, either directly or indirectly, which include allergic reactions, digestive system disturbances, and persistent toxic consequences from low-level exposure (Chen et al., 2019; Manyi-Loh, Mamphweli, Meyer, & Okoh, 2018). The World Health Organization (WHO) has highlighted that diseases caused by antibiotic-resistant bacteria are currently the leading global cause of mortality due to the emergence and spread of antibiotic resistance. Without prompt action, this situation is expected to worsen (Defoirdt, 2018; World Health Organization, 2014).

Furthermore, the public's lack of awareness regarding the harmful consequences of residual antibiotics in food on human health necessitates urgent and proper antibiotic management and control in aquaculture industries (Chen et al., 2019; Letchumanan, Ab Mutalib, Wong, Chan, & Lee, 2019). Using such antibiotics may have benefited the aquaculture industry's production and expansion. However, it has also garnered criticism due to the presence of antibiotic residues in cultured aquatic products, posing a potential health risk to humans (Chen et al., 2019). Consequently, it becomes imperative to confront these concerns head-on by adopting responsible aquaculture practices and employing advanced technologies. This dual approach aims to mitigate the environmental repercussions while simultaneously ensuring the protection of human health.

A major obstacle in addressing AMR issues in aquaculture is the high cost of proposed solutions, deterring farmers from adopting the necessary technologies. Accordingly, this limited technological adoption among farmers calls for accessible and improved technologies in the market to effectively address AMR challenges in shrimp farms. Thus, improved disease-prevention technologies can be incorporated into aquaculture practices through probiotics, antibodies, and green water systems. This strategy has demonstrated promising results in reducing bacterial diseases within the aquaculture industry. It is gaining popularity as a novel approach to managing bacterial biofilms in various industrial, medical, and water treatment settings, including aquaculture facilities (Bzdrenga et al., 2017; Rehman & Leiknes, 2018). The application of improved disease-prevention technologies is of paramount importance in the aquaculture industry, as it significantly influences the pathogenicity of aquatic host species (Nurarina, Aini, Ying, Ahmad, & Natrah, 2020). Embracing these technologies offers potential benefits to the aquaculture sector, ensuring enhanced disease management and fostering sustainable growth in the industry. However, the intentions of shrimp farmers regarding the adoption of improved disease-prevention technologies have not been extensively examined in Malaysia, particularly in the aquaculture industry.

Consequently, the development of improved disease-prevention technologies in shrimp farms, encompassing mass culture systems for new natural food sources, bioactive components, and natural and synthetic antibodies, holds the potential not only to mitigate AMR but also to provide multifaceted benefits to farmers. Therefore, this study aims to achieve the following objectives: (1) to determine shrimp farmers' intention level to adopt improved disease-prevention technologies in shrimp farming, (2) to determine the associations between farm profiles and farmers' intentions to adopt improved disease-prevention technologies in shrimp farming, and (3) to investigate factors influencing shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming.

RESEARCH METHOD

Sampling Method

Stratified random sampling was employed as a method in which the population was divided into distinct subgroups or strata, and a random sample was taken from each stratum. Following the guidelines proposed by Krejcie and Morgan (1970), a sample size of 123 shrimp farmers was determined. Therefore, responses were collected from shrimp farmers registered under the Department of Fisheries Malaysia (DoF) in four regions across Peninsular Malaysia: Northern, East Coast, Central, and Southern.

Research Instrument

To collect data, this study employed a survey research design with a structured questionnaire administered through face-to-face interviews, enabling data collection from a large number of respondents within a short timeframe (Adnan, Nordin, & Ali, 2018; Groves et al., 2011). The questionnaire comprised two sections: Section A focused on farm profiles, while Section B consisted of 31 statements related to attitude, perceived behavioral control, subjective norm, and perceived resources, rated on a 5-point Likert scale to allow for nuanced responses (Daxini et al., 2018; Ulhaq, Pham, Le, Pham, & Le, 2022). Informed consent was obtained from all participating shrimp farmers before the study.

Conceptual Framework

This study employed a conceptual framework based on the theory of planned behavior (TPB) developed by Ajzen (1991) to determine shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming, as illustrated in Figure 1. The TPB posits that behavior is influenced by a person's willingness and ability to engage in that behavior, whether individually or with others (Ajzen, 1991; Bagheri, Bondori, Allahyari, & Damalas, 2019). It emphasizes that a person's attitude, perceived behavioral control, and subjective norms significantly impact his behavioral intentions (Ajzen, 1991; Bagheri et al., 2019; Ulhaq et al., 2022). The TPB framework has been widely acknowledged for its logical yet adaptive approach to understanding farmers' technology adoption decisions (Adnan et al., 2018; Borges et al., 2019). In this study, two additional key factors were explored: perceived resources and farm profiles. These aspects were informed by prior research conducted by Daxini et al. (2018) and Jan (2021) and Payen et al. (2022).

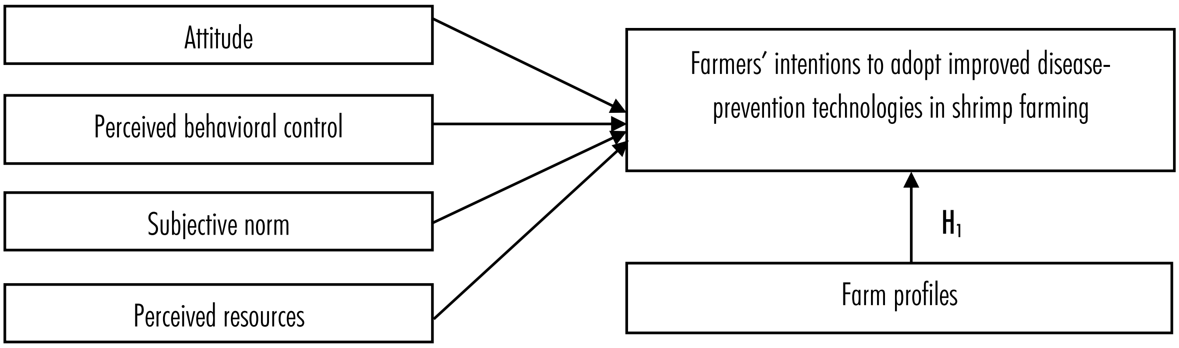

FIGURE 1. CONCEPTUAL FRAMEWORK OF FARMERS' INTENTIONS TO ADOPT IMPROVED DISEASE-PREVENTION TECHNOLOGIES IN SHRIMP FARMING
SOURCE: ADAPTED FROM DAXINI ET AL. (2018) AND AJZEN (1991)

The hypotheses developed for this study were drawn from a comprehensive review of relevant literature, with specific references to the works of Jan (2021). The formulated hypotheses are that there are associations between farm profiles and shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming.

Statistical Analysis

Several statistical analyses were conducted to address the study's objectives. Descriptive analysis was utilized to assess the level of intentions of shrimp farmers toward adopting improved disease-prevention technologies in shrimp farming. The questionnaire included five statements to measure their intentions, with responses rated on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). Mean scores were calculated to determine shrimp farmers' intentions. A mean score falling within the range of 1.0 to 3.66 indicated low intention, while a mean score ranging from 3.67 to 5.0 indicated high intention (Azman, D Silva, Samah, Man, & Shaffril, 2013; Ghani, Ahmad, & Ibrahim, 2014; Nazuri, Man, Saufe, & Nazuri, 2018).

Chi-square analysis was employed to investigate the associations between farm profiles and the intentions of shrimp farmers to adopt improved disease-prevention technologies in shrimp farming. The significance value was set at 0.1 (10%), 0.05 (5%), or 0.01 (1%) to establish the statistical significance of the relationship between the variables. Factor analysis was utilized to identify the underlying factors influencing shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming. By combining related variables into coherent components, factor analysis offers valuable insights (Verma & G. Abdel-Salam, 2019). For accurate implementation, Bartlett's test of sphericity was applied to ensure the significance of the data ($p<0.05$), while the Kaiser-Meyer-Olkin (KMO) test determined the suitability of the data for factor analysis (Shrestha, 2021). A reliability analysis was performed to assess the reliability of the measurement method in capturing the essence of the subject under investigation. Cronbach's alpha coefficient, which must exceed 0.60 (Ahmad@Mohamad, 2016), was adopted to evaluate the consistency of assessment items within a construct.

Lastly, logistic regression analysis was employed to explore the factors influencing shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming. As described by Pallant (2010), the dependent variable in logistic regression analysis is binary or dichotomous, containing values coded as either 1 or 0. In this study, responses such as "strongly disagree," "disagree," and "neutral" were combined into the category "do not intend" and categorized as 0, following the approach used in previous studies by Daxini et al. (2018) and Hyland et al. (2018). Conversely, responses "agree" and "strongly agree" were classified as 1. With only two types of responses, a binary logistic model was deployed to investigate the relationship between the hypothesized psychological factors and the likelihood that a farmer indicates a "yes" response (positive intention) to adopt improved disease-prevention technologies in shrimp farming. This relationship can be expressed using the following Equation 1:

$$ln\left[\frac{P_i}{1\text{-}P_i}\right] = \beta_0 + \beta_1\chi_{1i} + \beta_2\chi_{2i} + \ldots + \beta_k\chi_{ki} + \varepsilon \quad (1)$$

$ln\left[\frac{P_i}{1\text{-}P_i}\right]$ indicates farmers' intentions to adopt improved disease-prevention technologies in shrimp farming; $ß_0$ is constant; and $ß_1$–$ß_k$ refer to the coefficient of χ_1-χ_k, χ_1, χ_2, χ_3, χ_4 consisting of attitude, perceived behavioral control, subjective norm, perceived resources (Dichotomous - Factor score). Additionally, the equation involved several variables: χ_5 denotes farmers' experience (0 = less experience, 1 = more experience), χ_6 signifies farm size (0 = small farm, 1 = large farm), χ_7 implies monthly revenue (0 = low revenue, 1 = high revenue), and χ_8 depicts relevant training (0 = no, 1 = yes).

RESULTS AND DISCUSSION

Farm Profiles

Descriptive analysis was utilized to summarize the farm profiles of the 123 participating shrimp farmers. Table 1 presents the key findings, providing insights into various aspects of their farming practices. It was revealed that a significant portion of shrimp farms were established between 2011 and 2020 (40.7%, n=50), indicating a relatively recent entry into the industry for many farmers. Additionally, a considerable number of farmers reported having worked in the field for around 14-20 years (43.9%, n=54), showcasing a mix of experienced farmers and newcomers. These findings offer valuable insights into the characteristics and circumstances of the participating shrimp farmers, providing a foundation for understanding the dynamics of technology adoption in the shrimp farming industry.

Shrimp Farmers' Intentions to Adopt Improved Disease-Prevention Technologies

Table 2 displays the set of five statements used to assess shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming. The findings shed light on their willingness to embrace technological advancements. A significant proportion of the shrimp farmers (32.5%, n=40) strongly agreed that they would utilize the improved technologies if these technologies could boost their farming productivity, indicating a positive intention with a mean score of 4.05. The average mean score for shrimp farmers' intentions was 4.008, highlighting a significant positive inclination among the shrimp farmers toward adopting improved disease-prevention technologies in shrimp farming.

TABLE 1. FARM PROFILES

Profile	Classification	Frequency (n)	Percentage (%)
Year of establishment	1990-2000	26	21.1
	2001-2010	47	38.2
	2011-2020	50	40.7
Farmers' experience	0-6	26	21.1
	7-13	28	22.8
	14-20	54	43.9
	21 and above	15	12.2
Certification of Good Aquaculture Practices (GAqP)	Yes	18	14.6
	No	105	85.4
Farm record	Yes	122	99.2
	No	1	0.8
Farm size (hectare)	10-20	46	37.4
	21-30	46	37.4
	31-40	26	21.1
	41 and above	5	4.1

Profile	Classification	Frequency (n)	Percentage (%)
Pond size (m^2)	Below 1,000	19	15.4
	1,001-5,000	40	32.5
	5,001-10,000	47	38.2
	10,001-15,000	17	13.8
Monthly revenue (RM)	10,000-20,000	63	51.2
	20,001-30,000	36	29.3
	30,001-40,000	24	19.5
Relevant training	Yes	66	53.7
	No	57	46.3
Extension service	Yes	29	23.6
	No	94	76.4

Note: n= 123

TABLE 2. SHRIMP FARMERS' INTENTIONS TO ADOPT IMPROVED DISEASE-PREVENTION TECHNOLOGIES

No.	Statement (Intention)	Responses (n)					Mean	Std. dev.
		1	2	3	4	5		
1.	I am willing to use the improved disease-prevention technologies if they can increase productivity in my shrimp farming.	1 (0.8%)	2 (1.6%)	27 (22.0%)	36 (29.3%)	40 (32.5%)	4.05	0.828
2.	I would consider using the improved disease-prevention technologies in my shrimp farming.	1 (0.8%)	2 (1.6%)	26 (21.1%)	55 (44.7%)	39 (31.7%)	4.05	0.818
3	I intend to use the improved disease-prevention technologies in my shrimp farming when they become available in the market later.	1 (0.8%)	1 (0.8%)	31 (25.2%)	53 (43.1%)	37 (30.1%)	4.01	0.815
4.	I have the intention to use any improved disease-prevention technologies in my shrimp farming.	1 (0.8%)	3 (2.4%)	29 (23.6%)	52 (42.3%)	38 (30.9%)	4.00	0.849
5.	I have the intention to use the improved disease-prevention technologies in my shrimp farming.	1 (0.8%)	5 (4.1%)	38 (30.9%)	36 (29.3%)	43 (35.0%)	3.93	0.947
Average mean:							**4.008**	**0.851**

Note: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree

Shrimp Farmers' Intention Level to Adopt Improved Disease-Prevention Technologies

Table 3 exhibits the levels of shrimp farmers' intentions toward adopting improved disease-prevention technologies in shrimp farming. Intentions were classified into two categories: high (3.6-5.0) and low (1.0-3.59) based on the previous studies conducted by Nazuri et al. (2018), Ghani et al. (2014) and Azman et al. (2013). The outcomes indicated that 74% (n=91) of shrimp farmers had a high intention to adopt improved disease-prevention technologies in shrimp farming, while 26% (n=32) expressed a low intention. According to

Kumar, Engle, and Tucker (2018), increased productivity is a key driver in adopting a technology because producers prefer technologies providing a bigger relative advantage in terms of production and cost. Hence, these findings provide valuable insights into the overall intentions of shrimp farmers, underscoring the favorable inclinations toward adopting improved disease-prevention technologies. These elevated intentions offer a promising outlook for the extensive integration of these technologies, thereby making significant contributions to the progression of the shrimp farming industry in Malaysia.

TABLE 3. SUMMARY OF SHRIMP FARMERS' INTENTION LEVEL ON IMPROVED DISEASE-PREVENTION TECHNOLOGIES

Intention Level (Mean score)	Frequency (n)	Percentage (%)
High intention (3.6-5.0)	91	74.0
Low intention (1.0-3.59)	32	26.0

Associations Between Farm Profiles and Shrimp Farmers' Intentions to Adopt Improved Disease-Prevention Technologies

Chi-square analysis was employed to investigate the associations between farm profiles and shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming. The results in Table 4 demonstrate statistically significant associations between farm profiles and shrimp farmers' intentions to adopt these technologies, with significance levels of 5% and 10%. Consequently, H0 was rejected, indicating the existence of associations between farm size ($\chi2$=9.506, p <0.023), relevant training ($\chi2$=4.542, p <0.033), farmers' experience ($\chi2$=8.360, p <0.039), monthly revenue ($\chi2$=4.970, p <0.083), and their intentions to adopt improved disease-prevention technologies in shrimp farming.

TABLE 4. ASSOCIATIONS BETWEEN FARM PROFILES AND SHRIMP FARMERS' INTENTIONS TO ADOPT IMPROVED DISEASE-PREVENTION TECHNOLOGIES

Variables	Value	df	Sig.	Decision
Year of establishment	0.580	2	0.445	Fail to reject H_0
Farmers' experience	8.360	3	0.039**	Reject H_0
Certification of GAqP	0.587	1	0.444	Fail to reject H_0
Farm record	0.355	1	0.552	Fail to reject H_0
Farm size	9.506	3	0.023**	Reject H_0
Pond size	3.254	3	0.354	Fail to reject H_0
Monthly revenue	4.970	2	0.083*	Reject H_0
Relevant training	4.542	1	0.033**	Reject H_0
Advisory assistant	0.559	1	0.455	Fail to reject H_0

Note: **Significant at a 5% level of significance; *Significant at a 10% level of significance

Furthermore, Kebede and Keba (2020) have highlighted that experienced farmers are more adept at adopting new technologies compared to less experienced farmers. Moreover, the significance of farm size as an influencing factor aligns with the findings of Abdulai and Huffman (2014), who observed that farmers with larger farm sizes tended to be more open to adopting modern technologies. Similarly, Darkwah, Kwawu, Agyire-Tettey, and Sarpong (2019) reported that farmers with larger farm sizes were more likely to embrace modern technologies in their practices. Additionally, Darkwah et al. (2019) discovered that relevant training played a crucial role in increasing awareness and encouraging the adoption of current technologies among farmers. These results demonstrate the significance of various farm profiles as influential factors in shaping shrimp farmers' intentions to adopt improved disease-prevention technologies. The findings offer valuable insights into the potential determinants driving technology adoption in the shrimp farming industry.

Factors Influencing Shrimp Farmers' Intentions to Adopt Improved Disease-Prevention Technologies

Factor analysis was performed to identify the key factors influencing shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming. The adequacy of the sample size and the suitability of the selected statement items for factor analysis were assessed using the KMO test, resulting in a favorable value of 0.810 (Shrestha, 2021). Additionally, Bartlett's test of sphericity yielded a statistically significant result at the 1% level, confirming the relevance of the statement items for the factor analysis. Table 5 lists the four factors identified to influence shrimp farmers' intentions regarding the adoption of improved disease-prevention technologies in shrimp farming: attitude, perceived behavioral control, subjective norm, and perceived resources. These items demonstrated convergent validity, with factor loadings at 0.5 or higher (Hair, 2011). These four factors collectively explained approximately 85.58% of the variance in shrimp farmers' intentions to adopt improved disease-prevention technologies. A reliability test using Cronbach's alpha was performed to ensure the reliability of the factors. All statement items displayed coefficients over 0.60, indicating acceptable reliability (Sekaran & Bougie, 2016). Consequently, the results of the factor analysis offer valuable insights into the key underlying factors influencing shrimp farmers' intentions toward adopting improved disease-prevention technologies in their practices.

The first factor identified was attitude, comprising six sub-variables with a total variance of 54.705% and eigenvalues of 13.129. This factor explained the highest total variance of 54.705%, signifying its significant role in shaping shrimp farmers' intentions to adopt the technologies. Strong associations between a positive attitude and the intentions to adopt the technologies were indicated by factor loadings ranging from 0.939 to 0.898. The Cronbach's alpha for attitude was 0.973, demonstrating high internal consistency. The second factor influencing shrimp farmers' adoption intentions was perceived behavioral control, consisting of five sub-variables with a total variance of 18.013% and eigenvalues of 4.323. The factor loadings ranged between 0.909 and 0.602, implying that perceived behavioral control had a notable impact on farmers' intentions. The Cronbach's alpha for perceived behavioral control was 0.897.

The third factor, subjective norms, included six sub-variables with a total variance of 7.345% and eigenvalues of 1.763. The factor loadings were in the range of 0.876 to 0.760, suggesting that subjective norms could influence farmers' intentions to adopt improved disease-prevention technologies. The Cronbach's alpha for subjective norms was 0.962. Furthermore, the perceived resources factor had eigenvalues of 1.324 and a total variance of

5.515%, comprising seven sub-variables. The factor loadings ranged between 0.858 and 0.780, indicating that perceived resources significantly influenced farmers' intentions to adopt improved disease-prevention technologies. The Cronbach's alpha for perceived resources was 0.978.

TABLE 5. A SUMMARY OF FACTORS EXPLAINING SHRIMP FARMERS' INTENTIONS TO ADOPT IMPROVED DISEASE-PREVENTION TECHNOLOGIES

Items		Factor Loading
Factor 1: Attitude		
1.	I will use the improved disease-prevention technologies in my shrimp farming if they can increase profits.	0.939
2.	I will use the improved disease-prevention technologies in my shrimp farming if they can lower the cost of input.	0.934
3.	I will use the improved disease-prevention technologies in my shrimp farming if they can produce good-quality shrimps.	0.922
4.	I will use the improved disease-prevention technologies in my shrimp farming if they can increase productivity.	0.921
5.	I will use the improved disease-prevention technologies in my shrimp farming if they can reduce the disease problems.	0.908
6.	I will use the improved disease-prevention technologies in my shrimp farming if they can preserve the environment.	0.898
Eigenvalues		13.129
Percentage of variance explained		54.705
Cronbach's Alpha		0.973
Factor 2: Perceived behavioral control		
1.	I will use the improved disease-prevention technologies in my shrimp farming if they are under my supervision.	0.909
2.	I will use the improved disease-prevention technologies in my shrimp farming if all the technology-related decisions are made by me.	0.880
3.	I will use the improved disease-prevention technologies in my shrimp farming if I have the opportunity to use them.	0.638
4.	I will use the improved disease-prevention technologies in my shrimp farming if I have a better understanding of how to use them.	0.636
5.	I will use the improved disease-prevention technologies in my shrimp farming if I am able to use them well.	0.602
Eigenvalues		4.323
Percentage of variance explained		18.013
Cronbach's Alpha		0.897
Factor 3: Subjective norm		
1.	I will use the improved disease-prevention technologies in my shrimp farming if the government provides incentives to use them.	0.876
2.	I will use the improved disease-prevention technologies in my shrimp farming if other shrimp farmers encourage me to use them.	0.830
3.	I will use the improved disease-prevention technologies in my shrimp farming if the government provides low loan installment rates.	0.812
4.	I will use the improved disease-prevention technologies in my shrimp farming if other shrimp farmers convey the information.	0.787
5.	I will use the improved disease-prevention technologies in my shrimp farming if I get help from the government.	0.780
6.	I will use the improved disease-prevention technologies in my shrimp farming if other shrimp farmers also use them.	0.760
Eigenvalues		1.763
Percentage of variance explained		7.345
Cronbach's Alpha		0.962
Factor 4: Perceived resources		
1.	I will use the improved disease-prevention technologies in my shrimp farming if I have adequate financial resources.	0.858
2.	I will use the improved disease-prevention technologies in my shrimp farming if I have employees who are skilled in handling them.	0.839
3.	I will use the improved disease-prevention technologies in my shrimp farming if they are affordable.	0.832
4.	I will use the improved disease-prevention technologies in my shrimp farming if I get a low-rate loan from the relevant agency.	0.825
5.	I will use the improved disease-prevention technologies in my shrimp farming if I have complete knowledge and information.	0.823
6.	I will use the improved disease-prevention technologies in my shrimp farming if I have enough employees to use them.	0.807
7.	I will use the improved disease-prevention technologies in my shrimp farming if I have enough time to use them.	0.780
Eigenvalues		1.324
Percentage of variance explained		5.515
Cumulative percentage		85.578
Cronbach's Alpha		0.978

Factors that Mostly Influenced Shrimp Farmers' Intentions to Adopt Improved Disease-Prevention Technologies

Logistic regression analysis was employed to investigate the factors with the greatest influence on shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming. Table 6 depicts the statistical significance of four factors: farmers' experience, attitude, subjective norm, and perceived resources, in relation to shrimp farmers' intentions. The Cox and Snell's and Nagelkerke's R^2 results indicated that the overall model explained between 0.467 and 0.684 of the variance that could be predicted by the independent variables. The Hosmer and Lemeshow p-value was 0.828, which exceeded 0.05, confirming that the estimated model adequately fit the data.

TABLE 6. FACTORS THAT MOSTLY INFLUENCED SHRIMP FARMERS' INTENTIONS TO ADOPT IMPROVED DISEASE-PREVENTION TECHNOLOGIES IN SHRIMP FARMING

Variables	Estimated coefficients	Standard error (S.E.)	Wald	Significant	Exponential (B)
Farmers' experience	1.767	0.735	5.779	0.016**	5.855
Farm size	1.108	0.809	1.876	0.171	3.028
Relevant training	0.947	0.679	1.944	0.163	2.577
Monthly revenue	-0.736	0.953	0.596	0.440	0.479
Attitude	2.062	0.572	13.011	0.00***	7.864
Perceived behavioral control	0.380	0.353	1.164	0.281	1.463
Subjective norms	1.627	0.503	10.484	0.001***	5.090
Perceived resources	1.370	0.442	9.625	0.002***	3.937
Constant	-0.400	0.856	0.219	0.640	0.670
-2 log-likelihood	63.688		Nagalkerke R square		0.684
Cox & Snell square	0.467		Hosmer & Lemeshow test		0.828

Note: ***p<0.01; **p<0.05; *p<0.10

The analysis revealed a significant positive relationship between attitude (ß=2.062, p<0.000) and the intentions of shrimp farmers to adopt improved disease-prevention technologies in shrimp farming. Shrimp farmers with favorable attitudes were 7.9 times more likely to have the intention to adopt these technologies. Consequently, attitude was revealed as the most influential factor affecting shrimp farmers' adoption intentions. These findings are consistent with previous research by Daxini et al. (2018) and Zeweld, Van Huylenbroeck, Tesfay, and Speelman (2017), emphasizing that farmers' intentions to adopt technologies were strongly influenced by their attitude toward technology-related aspects. Castillo, Engler, and Wollni (2021) concurred that a favorable attitude significantly influenced the intentions to adopt irrigation technologies in Chile. Farmers' experience (ß=1.767, p<0.016) exhibited a positive relationship, indicating that those with more experience in shrimp farming were 5.9 times more likely to adopt the improved technologies in their shrimp farming. This finding aligns with (Abdulai, Owusu, and Bakang, 2011), concluding that farmers' experience significantly influenced the adoption of agricultural innovations and technological advances. Farmers with more years of experience are better equipped to acquire knowledge and explore technologies suited to their production constraints (Ullah, Khan, Zheng, & Ali, 2018).

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Additionally, the subjective norm variable (ß=1.627, p<0.001) was positively related, indicating that surrounding influences exerted 5.1 times the likelihood for shrimp farmers to adopt the improved disease-prevention technologies. Ulhaq et al. (2022) stated that shrimp farmers could be highly influenced by the reactions of other influential figures to the potential use of ICT in shrimp production. Moreover, according to Castillo et al. (2021), many farmers learn not solely by testing new technologies in their farming but also by discussing experiences with their closest companions. Moreover, perceived resources (ß=1.370, p<0.002) significantly and positively affected shrimp farmers' intentions to adopt improved disease-prevention technologies, suggesting that farmers with sufficient resources, such as financial capacity, were 3.9 times more likely to adopt the technologies. This finding aligns with prior research investigating the impact of perceived resources on the adoption of new farming methods (Barnes et al., 2019; Daxini et al., 2018; Payen et al., 2022).

In conclusion, the findings unequivocally establish that attitude played a paramount role in shaping shrimp farmers' intentions to adopt improved disease-prevention technologies in shrimp farming, particularly in Peninsular Malaysia. This critical factor significantly influenced their decision-making and adoption behaviors. The estimated equation model is as follows:

$$\textit{Shrimp farmers' intentions} = -0.400 + 1.767\ \textit{farmers' experince} + 2.062\ \textit{attitude} + 1.627\ \textit{subjective norm} + 1.370\ \textit{perceived resource} + \varepsilon$$

CONCLUSION

This study investigated the intentions of shrimp farmers to adopt improved disease-prevention technologies. Given the advancements in technology, such as probiotics, antibodies, and green water systems, the findings of this study offer valuable insights to shrimp farmers regarding the adoption of these improved technologies. The study holds particular relevance for shrimp farmers engaged in the production of whiteleg shrimp (*Penaeus vannamei*) and giant tiger prawn (*Penaeus monodon*) because it is crucial to averting disease outbreaks within their operational processes. Encouragingly, transitioning away from the indiscriminate use of antibiotics and antimicrobial medications in shrimp production could have long-term benefits for human health and the environment. The availability of improved technologies in the market could effectively address disease challenges and reduce reliance on harmful practices. Besides, the novelty of this study highlights that previous research predominantly concentrated on farmers' intentions to implement agricultural practices (Castillo et al., 2021; Pahang, Nasirun, Mohd Nor, Anuar, & Saputra, 2021; Terano, Mohamed, Shamsudin, & Latif, 2015) and agricultural technologies (Adnan et al., 2018; Irianto, Mujiyo, Riptanti, & Qonita, 2020). However, there is a noticeable dearth of studies examining farmers' intentions specifically concerning aquaculture technologies, particularly in Malaysia (Ulhaq et al., 2022).

In the scope of this study, it became evident that among the factors influencing the adoption of improved disease-prevention technologies, attitude emerged as the most significant determinant. Therefore, to foster a positive attitude, shrimp farmers require adequate knowledge and support in handling the technologies. Advancing the understanding of technological advancements for disease prevention among shrimp farmers necessitates dedicated education and training initiatives. Implementing targeted programs and training sessions could empower farmers with the essential knowledge and skills, enabling them to adopt and utilize modern technologies for enhanced effectiveness adeptly. Hence, governmental and relevant agencies have assumed a pivotal role in highlighting the advantages of embracing these technologies. Their responsibility has extended to minimizing cost inputs, mitigating disease challenges, and preserving the environment, along with the provision of essential training and educational resources. Demonstrating the successful use of improved technologies on pioneer farms established under the Department of Fisheries Malaysia (DoF) could also enlighten other farmers about the benefits and practicality of technology adoption. In addition, it could be achieved through seminars, corporate meetings, online forums, and public awareness initiatives. Government agencies could also offer instructions, films, conferences, and interactive workshops that equip people with more understanding and encourage them to accept and use the technologies.

The information from this study holds value for the government and associated agencies, as it could aid in developing persuasive strategies to encourage the adoption of disease-prevention technologies in shrimp farming that could solve the diseases and uncontrolled use of antibiotics at the farm level. Besides, it promotes aquaculture development in Malaysia by encouraging the usage of disease-prevention technologies in shrimp farming and helps expand the farmers' perspectives and understanding before selecting the technologies. The ultimate goal is to empower the aquaculture industry through technological advancement while safeguarding the environment and promoting the health and well-being of both animals and humans. Promoting sustainable and responsible could ensure the long-term success and resilience of the shrimp farming sector.

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