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THEORETICAL AND CONCEPTUAL ANALYSIS: AFLATOXIN INTERVENTION OF MINDANAO, PHILIPPINES

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KEY WORDS:
aflatoxin intervention, health belief model, social cognitive theory, agricultural practices, food safety

ABSTRACT
This study examines the Aflatoxin Intervention Program being implemented by the Department of Agriculture Regional Field Office 10 in Bukidnon, Northern Mindanao, Philippines, through the lenses of the Health Belief Model (HBM) and Social Cognitive Theory (SCT). Using a descriptive, correlational, survey design, the data from 34 corn farmers across six municipalities were analyzed. The design analyzes their awareness of aflatoxin toxicity, adoption of mitigation protocols and access to media platforms. Findings show high awareness and adoption of aflatoxin mitigation protocols, but a significant part of the participants remains unaware, thus indicating growth points for improvement. High awareness of the mitigation protocols suggest that communication strategies have been effective and observational learning is critical in the awareness process. High adoption rates among early and mainstream adopters of the mitigation protocols convey practical impact of the awareness and educational programs of the department. Media platform access shows weak impact, highlighting the need for more interactive educational strategies. Strong correlations between awareness and adoption rates validate HBM and SCT principles, emphasizing perceived severity, benefits, and self-efficacy. Insights into effective communication strategies underline the importance of targeted, community-based interventions that promote adoption of aflatoxin mitigation protocols. These findings contribute to food safety and wider adoption of good agricultural practices in corn cultivation, providing a framework for future studies and interventions to enhance aflatoxin management in Northern Mindanao.

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ТЕОРЕТИЧЕСКИЙ И КОНЦЕПТУАЛЬНЫЙ АНАЛИЗ: КОНТРОЛЬ СОДЕРЖАНИЯ АФЛАТОКСИНА НА ТЕРРИТОРИИ МИНДАНАО, ФИЛИППИНЫ

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КЛЮЧЕВЫЕ СЛОВА:
контроль содержания афлатоксина, модель веры в здоровье, теория социального научения, сельскохозяйственные методы, безопасность продуктов питания

АННОТАЦИЯ
В этом исследовании рассматривается Программа контроля содержания афлатоксина, проводимая главным управлением региональной службы 10 министерства сельского хозяйства в Букидноне, провинция Северный Минданао, Филиппины, через призму модели веры в здоровье (МВЗ) и теории социального научения (ТСН). Используя метод описания, корреляционного анализа и опроса были проанализированы данные, полученные от 34 фермеров, выращивающих кукурузу, в шести муниципалитетах. План статистического обследования анализирует их осведомленность о токсичности афлатоксина, принятие протоколов смягчения воздействия афлатоксина, и наличие доступа к медиаплатформам. Результаты показывают высокую осведомленность и принятие протоколов смягчения воздействия афлатоксина, но значительная часть опрошенных остается неосведомленной, что указывает на области работ над улучшением ситуации. Высокая осведомленность о протоколах смягчения воздействия афлатоксина свидетельствует о том, что стратегии коммуникации оказались эффективными, а обучение через наблюдение имеет решающее значение в процессе создания осведомленности. Высокие показатели принятия протокола среди тех лиц, кто одними из первых примкнул к соблюдению таковым протокола, и лиц, которые позже составили основную массу последователей протоколов смягчения воздействия афлатоксина, передают далее практический эффект программ повышения осведомленности и образовательных программ министерства. Доступ к медиаплатформам оказывает слабое воздействие, подчеркивая необходимость в применении более интерактивных образовательных стратегий. Прочная корреляция между осведомленностью и уровнем принятия протокола подтверждают принципы МВЗ и ТСН, подчеркивая серьезность восприятия, получаемые преимущества и уверенность в собственных силах. Понимание эффективных стратегий коммуникации подчеркивает важность применения целевых корректирующих программ на уровне общества, что способствуют принятию протоколов по смягчению воздействия афлатоксина. Эти результаты способствуют обеспечению безопасности продуктов питания, и более широкому принятию надлежащих сельскохозяйственных практик в отношении возделывания кукурузы, обеспечивая основу для будущих исследований и корректирующих программ, направленных на контроль содержания афлатоксина в Северном Минданао.

1. Introduction

The increasing concern over food safety and security has brought to the forefront the necessity for effective management of aflatoxin contamination, particularly in regions where staple crops are highly susceptible to it [1,2,3]. Aflatoxin contamination in food and crops has been a global problem compromising food safety and agricultural economics [2,4,5,6]. In Northern Mindanao, Philippines, the Aflatoxin Intervention Program initiated by the Department of Agriculture Regional Field

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Office 10 aims to address this critical issue [7,8]. This study focuses on providing theoretical insights and a conceptual analysis of the program, guided by the Health Belief Model [9,10,11,12,13]. The general purpose is to understand the dynamics of awareness, mitigation, and adoption among the corn farmers in Bukidnon within the context of aflatoxin content control.

The first objective of this study, therefore, is to explore farmers' awareness of aflatoxin toxicity. Awareness is a foundational element for understanding the severity and susceptibility of crops to aflatoxin contamination. Without adequate awareness, farmers may not fully grasp the risks associated with aflatoxin, resulting to the insufficient preventive measures [14,15,16,17]. This study aims to fill the gap in knowledge by assessing the current level of awareness among the corn farmers in Bukidnon and identifying the factors that contribute to or hinder their understanding of aflatoxin toxicity [18]. By grounding this exploration on the Health Belief Model, the study aims to provide a nuanced understanding of how perceived risks influence the farmers' awareness and guide their subsequent actions.

The second objective delves into the awareness and adoption of mitigation protocols. Effective mitigation strategies are essential to reduce aflatoxin levels in the crops and ensure food safety [14]. However, awareness of these protocols does not automatically converse into their adoption. This study seeks to understand the extent to which farmers are aware of the recommended mitigation protocols and the factors influencing their adoption. By utilizing Social Cognitive Theory [13], the study will analyze how observational learning, self-efficacy, and social norms influence the farmers' decisions to adopt these practices. This objective addresses the gap in knowledge regarding the transition from awareness to action in the context of aflatoxin control [19].

The third objective focuses on the sources of information through which the farmers learn about aflatoxin mitigation protocols. In the digital age, various media platforms play a crucial role in distributing information [20]. This study examines the effectiveness of various media channels used by the Department of Agriculture to raise awareness about aflatoxin. It seeks to find out which media platforms are most effective in reaching the farmers and influencing their knowledge and behaviors. By evaluating the impact of traditional media, social media, and direct training programs, this study aims to provide insights into the most efficient communication strategies for future interventions.

Addressing these objectives will fill significant gaps in the existing literature on aflatoxin management. The findings will provide insightful understanding of the current state of awareness and adoption of mitigation protocols among corn farmers in Bukidnon. Additionally, the study will offer practical recommendations for enhancing communication strategies to improve the distribution of crucial information. By integrating theoretical frameworks with empirical data, the study aims to contribute to the broader discourse on food safety and agricultural practices.

Moreover, the theoretical basics of this study, specifically the Health Belief Model and Social Cognitive Theory, provide a robust framework for analyzing the dynamics of aflatoxin management. Health Belief Model focuses on the cognitive factors that influence health-related behaviors, such as perceived susceptibility and severity of aflatoxin contamination. Social Cognition Theory, on the other hand, emphasizes the role of social influences and self-efficacy in adopting new practices [9,13]. Together, these theories offer a comprehensive approach through which it is possible to review the complexities of awareness and adoption of aflatoxin mitigation strategies.

In Bukidnon, the leading corn producing region in Northern Mindanao, the implications caused by aflatoxin contamination are significant [21,22]. High aflatoxin levels can lead to severe health issues, including liver cancer and stunted growth in children [6,23]. Therefore, understanding and addressing the gaps in knowledge and practices related to aflatoxin management is crucial for the well-being of the community. This study's focus on theoretical insights and practical assessments are aimed to provide a holistic understanding of the Aflatoxin Intervention Program's effectiveness.

Although the sample size and task-oriented sampling method used in this study are limitations that need to be acknowledged, however, by framing the research within reliable theoretical frameworks, the study aims to provide valuable conceptual insights that can inform about future interventions and studies. The goal is not to generalize the findings in common, but to offer a detailed analysis that can guide targeted improvements in the Aflatoxin Intervention Program.

By focusing on awareness, mitigation, and adoption, this study addresses critical areas that are essential for the success of any intervention program implementation. Awareness of the dangers of aflatoxin is the first step toward effective management. Understanding the factors that influence the adoption of mitigation protocols ensures that farmers are not only informed, but are also motivated to take actions [24]. Evaluating the sources of information helps identify the most effective communication strategies, ensuring that vital information reaches the intended audience [25].

From this perspective, this study aims to provide a thorough theoretical and practical analysis of the Aflatoxin Intervention Program in Northern Mindanao. By leveraging the Health Belief Model and Social Cognitive Theory, the study offers a nuanced understanding of the factors influencing awareness, mitigation, and adoption among the corn farmers. The findings will fill significant gaps in the existing literature and provide practical recommendations for enhancing the program's effectiveness. This insightful approach will contribute to the more comprehensive goal of improving food safety and agricultural practices in the region.

2. Objects and methods

In light of the above discussions and theoretical basics, the study is focused on three primary objectives. Firstly, it seeks to understand how awareness, mitigation, and adoption behaviors among the corn farmers align with the principles of the Health Belief Model (HBM) and Social Cognitive Theory (SCT) within the context of the Aflatoxin Intervention Program. Secondly, it aims to analyze the farmers' responses to the intervention program through these theoretical frameworks to identify emerging patterns and insights. Lastly, the study endeavors to provide a conceptual framework that can guide future interventions and studies, ensuring more comprehensive approach to managing aflatoxin contamination. These objectives collectively aim to fill the significant gaps in current knowledge and practice, offering both theoretical and practical contributions to the field of aflatoxin management.

2.1. Hypotheses of the study

Building on these objectives, the study will delve deeper into the theoretical foundations and practical outcomes of the Aflatoxin Intervention Program. To test empirically our understanding, three hypotheses have been formulated. These hypotheses align with the principles of the Health Belief Model (HBM) and Social Cognitive Theory (SCT), focusing on how awareness influences understanding, how mitigation protocol awareness is converted into actionable solutions, and how the adoption of these protocols impacts aflatoxin contamination. Each hypothesis will be subjected to thorough statistical analysis to validate the conceptual framework and provide insights into the effectiveness of the intervention strategies. These hypotheses are as follows:

Hypothesis 1. Awareness of aflatoxin toxicity, guided by the Health Belief Model (HBM), will lead to a deeper understanding of the risks among corn farmers in Bukidnon.

Hypothesis 2. Mitigation protocol awareness and its alignment with Social Cognitive Theory (SCT) principles will provide the corn farmers with actionable solutions against aflatoxin contamination.

Hypothesis 3. Adoption of mitigation protocols, informed by both HBM and SCT, will effectively reduce aflatoxin contamination, showcasing the practical application of these theoretical frameworks.

2.2. Study area

The study was conducted in the province of Bukidnon, Northern Mindanao, Philippines. Bukidnon is a significant corn-producing region, with corn being its major agricultural product. The study specifically focused on six municipalities within Bukidnon: Damulog, Dangcagan, Kadingilan, Kitaotao, Kibawe, and Cabanglasan. These municipalities have been selected based on aflatoxin data from 2016 to 2021.

2.3. Participants

The study involved a diverse group of participants, including:

1) Key information officers in the Department of Agriculture — Regional Field Office 10 (DA-RFO 10), particularly corn operation personnel, the members of the regional GAP team, information personnel, and laboratory personnel who served from 2016 to 2021 and those who are currently serving as well.
2) Agricultural technicians and agriculture extension workers from local government units.
3) Corn farmers from the selected municipalities.

2.4. Criteria for corn farmer's selection

1) Membership in an association, cooperative, or people's organization within the municipality/city.
2) Experience in farming corn for at least one cropping season from 2016 to 2021.
3) Beneficiary of any program from the Department of Agriculture RFO 10 from 2016 to 2021.

2.5. Research design

The research concept involved descriptive, correlational, and survey research methods to provide a well-rounded examination of the Aflatoxin Intervention Program. The descriptive component captured the current state of awareness, mitigation practices, and adoption behaviors among the corn farmers in Bukidnon. Data were collected to depict the existing conditions and identify key characteristics of the target population. The correlational aspect explored the corcorrelation between the farmers' awareness of aflatoxin toxicity, their understanding and adoption of mitigation protocols, and the sources of information they used. Statistical techniques such as correlation analysis and regression were used to define the profoundness and direction of these corcorrelation.

Structured questionnaire was used to collect primary data directly from the corn farmers. These surveys gathered information on the farmers' levels of awareness, their adoption of mitigation protocols, and their use of various information sources. This method ensures the systematic collection of data, capturing the perspectives of actions and experiences of the target population.

2.6. Sampling method

Task-oriented non-random sampling was used to select the municipalities and the participants based on specific criteria. Each of the six municipalities provided in average five representatives for data collection. Data were gathered through the structured questionnaires, interviews, and focus group discussions. Key information officers and agricultural technicians provided insights into the implementation and impact of the intervention program. Corn farmers responded to the surveys regarding their awareness, mitigation practices, and adoption patterns of behaviors.

2.7. Data analysis

Descriptive statistics summarized the parameters of awareness levels, mitigation practices, and adoption patterns of behaviors. Correlation analysis determined the correlations between the awareness, understanding, and measures adoption. Regression analysis examined whether awareness of mitigation protocols might forecast the identification of actionable solutions.

Overall, this research design aims to provide a theoretically grounded and empirically grounded examination of the Aflatoxin Intervention Program's to the corn farmers in Bukidnon, Northern Mindanao. By integrating descriptive, correlational, and survey methods, the study offers valuable insights into the program's effectiveness and inform on future interventions and studies.

3. Results

The data presented in Tables 1, 2, 3, and 4, shows emerging patterns and insights that can substantiate the understanding of the Aflatoxin Intervention Program of the Department of Agriculture Regional Field Office 10.

3.1. Awareness of aflatoxin danger

Table 1. **Percentage distribution of the farmer's awareness of the danger of aflatoxin**

Таблица 1. **Процентное распределение степени осведомленности фермеров об опасности афлатоксина**

Descriptive scores		Awareness danger	%
2.35	3.00	Very aware	21.44
1.68	2.34	Aware	51.88
1.00	1.67	Unaware	26.68
Total (n = 34)			**100**

The data shows that 51.88% of farmers are "Aware" and 21.44% are "Very Aware" of the dangers of aflatoxin. However, 26.68% remain "Unaware". This shares distribution suggests that while awareness efforts have been moderately successful, a significant group of farmers still lack crucial knowledge.

This finding aligns with the first objective of understanding how awareness behaviors align with Health Belief Model (HBM) and Social Cognitive Theory principles (SCT). The high levels of awareness among the majority of involved population indicate successful distribution of information about aflatoxin risks, highlighting the perceived severity and susceptibility emphasized by HBM.

Theoretical Insights: According to Health Belief Model (HBM), the individuals are more likely to engage in health-promoting behaviors if they perceive a high risk (severity and susceptibility) and believe in the benefits of taking preventive actions. The Social Cognitive Theory (SCT) complements this by suggesting that observational learning and self-efficacy can enhance awareness levels. Farmers who are "Very Aware" are more likely to benefit from these combined influences.

3.2. Awareness of aflatoxin protocol

Table 2. Percentage distribution of farmer's awareness of aflatoxin protocol

Таблица 2. Процентное распределение степени осведомленности фермеров о протоколе контроля афлатоксина

Descriptive scores		Awareness of protocol	%
2.35	10	Very aware	28.02
1.68	18	Aware	52.45
1.00	7	Unaware	19.54
Total (n = 34)			**100**

The data indicates that 52.45% of farmers are "Aware" and 28.02% are "Very Aware" of the aflatoxin protocols. Only 19.54% are "Unaware". These numbers reflect a high level of awareness, suggesting effective communication of mitigation strategies.

This aligns with the second objective of analyzing the farmers' responses to the intervention program, especially how awareness of protocols equips the farmers with actionable solutions. The high awareness levels indicate that the farmers are well-informed about the available mitigation strategies.

From a Social Cognitive Theory perspective, this high awareness suggests that social influences and observational learning play significant roles. The farmers likely learn from their peers and agricultural experts who model these protocols. Health Belief Model further supports this by highlighting that perceived benefits of mitigation protocols drive awareness and potential adoption of the corrective measures.

3.3. Adoption of mitigation protocols

Table 3. **Percentage distributions of the farmers' rate of adoption of aflatoxin mitigation protocol**

Таблица 3. **Процентное распределение числа фермеров по уровню принятия протокола по снижению воздействия афлатоксина**

Descriptive scores		Rate of adoption of mitigation protocol	%
2.35	3.00	Early adopters	30.59
1.68	2.34	Mainstream adopters	51.00
1.00	1.67	Late adopters	18.41
Total (n = 34)			**100**

Table 3 shows that 30.59% of the farmers are early adopters, 51% are mainstream adopters, and 18.41% are late adopters of the aflatoxin mitigation protocols. This indicates a strong overall adoption rate, while most farmers incorporate these practices into their routine activities.

Furthermore, this data supports the third objective, which is to evaluate the adoption of mitigation protocols. The significant presence of early and mainstream adopters indicates that the awareness efforts have been converted into practical action, so crucial for the program's success.

On the other hand, Health Belief Model (HBM) suggests that individuals are more likely to adopt health behaviors if they perceive high benefits and low entry barriers. The high adoption rates suggest that farmers perceive the benefits of following mitigation protocols. Social Cognitive Theory emphasis on self-efficacy, and observational learning also explains why substantial portions of farmers have adopted these practices. The farmers, observing peers' successful adoption, build up confidence and encourage widespread uptake of those solutions.

3.4. Access to media platforms for aflatoxin awareness

The farmers' access to different media platforms for aflatoxin awareness varies. Training and seminars have the highest engagement at 20%, followed by brochures (14.5%) and video streaming sites (13.1%). Access to Department of Agriculture Regional Field Office 10 media platform 1 and their Website are notably lower.

This analysis addresses the first objective by evaluating the effectiveness of different media platforms in raising awareness. It is clear that interactive and accessible media such as training and seminars are more effective in reaching the farmers' attention.

According to Social Cognitive Theory, observational learning is pivotal. Training and seminars provide opportunities for the farmers to observe and learn from the experts and the peers, improving their confidence and self-efficacy. The Health Belief Model also suggests that perceived benefits from direct interaction and detailed learning methods enhance engagement and awareness.

Table 4. **Percentage distribution of the farmers that visited department of agriculture's media platform for aflatoxin awareness**

Таблица 4. **Процентное распределение числа фермеров, посетивших медиаплатформу Министерства сельского хозяйства для повышения своей осведомленности об афлатоксине**

Department of Agriculture Regional Field Office 10 — media platform for farmers to be aware of aflatoxin	Visited?
	Yes
	%
DA media platform 1	9.7
DA Website	9.0
Brochures	14.5
Training and seminar	20.0
Radio	11.7
Television	10.3
Video streaming sites (media platform 2)	13.1
Others	11.7

3.5. Emerging patterns and insights

Based on the above findings, we observe several emerging patterns. Firstly, there is high awareness but yet there is room for improvement. While the majority of the farmers are aware or very aware of aflatoxin dangers and protocols, there remains a significant group that is unaware, indicating a need for continued and targeted efforts for awareness raising. Secondly, there is effective adoption of protocols. The high adoption rates among early and mainstream adopters demonstrate the effectiveness of the mitigation protocols, validating the theoretical insights from Health Belief Model and Social Cognitive Theory about the importance of perceived benefits and social learning. Thirdly, there is preference for Interactive Learning. The farmers show a strong preference for interactive learning methods such as training and seminars, which are most effective in rising awareness and promoting adoption. This insight suggests that future interventions should continue to develop these interactive formats. Fourthly, the role of media platforms. The varied engagement with various media platforms highlights the need for a multi-faceted communication strategy that combines traditional and digital methods to maximize reach and impact.

In view of the above analyses and emerging patterns, it provides an insightful understanding of the current state of awareness, mitigation practices, and adoption behaviors among corn farmers in Bukidnon. By integrating Health Belief Model and Social Cognitive Theory, the study offers theoretical insights that underline the importance of perceived risks, benefits, and social influences in driving awareness and adoption.

Furthermore, the findings align with the study's objectives, demonstrating the program's strengths and identifying areas for improvement. This well-rounded examination not only evaluates the Aflatoxin Intervention Program but also contributes to the broader discourse on effective agricultural practices and food safety management.

3.6. Correlation between corn farmers' access to media platforms and awareness of aflatoxin protocols

Analysis: The data suggests a weak positive correlation between access to media platforms and awareness of aflatoxin protocols, but the correlation is not statistically significant. This indicates that merely accessing media platforms may not significantly enhance awareness of aflatoxin mitigation protocols among the farmers (Table 5).

This finding aligns with the first objective of understanding how awareness patterns of behaviors align with theoretical principles. It suggests that while media access is beneficial, other factors, possibly more interactive or targeted forms of information distribution, are necessary to significantly increase awareness.

Health Belief Model implies that perceived benefits and self-efficacy might drive awareness more than general media access. Social Cognitive Theory reinforces that observational learning and direct interaction play crucial roles. This finding suggests the need for more involving and direct educational methods.

3.7. Correlation between corn farmers' awareness of aflatoxin protocols and adoption of protocols

There is a very strong positive correlation between awareness of aflatoxin protocols and their adoption, and this correlation is statistically significant. The farmers who are more aware of protocols are significantly more likely to adopt them (Table 6).

This directly supports the second objective of analyzing farmer responses and the third objective of providing a conceptual framework. The strong correlation validates the importance of awareness in adoption of aflatoxin mitigation practices among the farmers.

Health Belief Model emphasis on perceived benefits and Social Cognitive Theory's focus on self-efficacy are evident here. Awareness clearly converts to higher adoption rates, reinforcing the importance of targeted awareness campaigns and educational interventions.

3.8. Correlation between corn farmers' access to media platforms and awareness of aflatoxin dangers

There is a weak positive correlation between access to media platforms and awareness of aflatoxin dangers, but it is not statistically significant (Table 7). This suggests that general media access alone does not significantly enhance awareness of the dangers posed by aflatoxin.

This aligns with the first objective and suggests that while media access is necessary, it is not sufficient to significantly impact awareness levels. More direct and engaging forms of information distribution are needed.

Table 5. **Results of the simple linear regression analysis between corn farmers' access to media platforms and awareness of aflatoxin protocols**

Таблица 5. **Результаты простого линейного регрессионного анализа между доступом фермеров, выращивающих кукурузу, к медиаплатформам, и осведомленностью о протоколах контроля афлатоксина**

Regression statistics	
Multiple R	0.257
R square	0.066
Adjusted R square	0.037
Standard error	0.568
Observations	34

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.730	0.730	2.261	0.143
Residual	32	10.334	0.323		
Total	33	11.064			

	Coefficients	Standard error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1.567	0.353	4.436	0.0001	0.847	2.286
Access to media platforms	0.304	0.202	1.504	0.142	−0.108	0.715

Table 6. **Results of the simple linear regression analysis between corn farmers' awareness of aflatoxin protocols and adoption of protocols**

Таблица 6. **Результаты простого линейного регрессионного анализа между осведомленностью фермеров, выращивающих кукурузу, о протоколах контроля афлатоксина, и принятием таковых протоколов**

Regression statistics	
Multiple R	0.955
R square	0.913
Adjusted R square	0.910
Standard error	0.183
Observations	34

ANOVA

	df	SS	MS	F	Significance F
Regression	1	11.207	11.207	335.663	1.584E-18
Residual	32	1.068	0.033		
Total	33	12.275			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.029	0.118	0.242	0.81	−0.212	0.269
Awareness of aflatoxin mitigation protocols	1.006	0.055	18.321	1.584E-18	0.895	1.118

Table 7. Results of the simple linear regression analysis between corn farmers' access to media platforms and awareness of aflatoxin dangers

Таблица 7. Результаты простого линейного регрессионного анализа между доступом фермеров, выращивающих кукурузу, к медиаплатформам, и их осведомленностью об опасностях афлатоксина

Regression statistics	
Multiple R	0.252
R square	0.063
Adjusted R square	0.034
Standard error	0.541
Observations	34

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.632	0.632	2.162	0.151
Residual	32	9.356	0.292		
Total	33	9.988			

	Coefficients	Standard error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1.469	0.336	4.374	0.0001	0.785	2.154
Access to media platforms	0.283	0.192	1.470	0.151	−0.108	0.674

Health Belief Model highlights that perceived susceptibility and severity are critical for awareness. Social Cognitive Theory suggests that observational learning and social modeling are the key factor. These findings indicate that passive media access is less effective than interactive, direct learning experiences.

3.9. Correlation between corn farmers' access to media platforms and adoption of aflatoxin protocols

There is a weak positive correlation between access to media platforms and adoption of aflatoxin protocols, but the correlation is not statistically significant (Table 8). This suggests that media access alone does not significantly facilitate the adoption of mitigation protocols.

This finding aligns with the second and third objectives, highlighting that while media platforms play a role, other factors such as direct training and seminars are more critical in promoting adoption of the protocol among the farmers.

Health Belief Model emphasizes perceived benefits, and Social Cognitive Theory stresses the importance of self-efficacy and observational learning. This suggests that farmers need more interactive and confidence-building experiences to adopt new practices effectively.

Table 8. **Results of the simple linear regression analysis between corn farmers' access to media platforms and adoption of aflatoxin protocols**

Таблица 8. **Результаты простого линейного регрессионного анализа между доступом фермеров, выращивающих кукурузу, к медиаплатформам, и их принятием протоколов контроля афлатоксина**

Regression statistics	
Multiple R	0.257
R square	0.066
Adjusted R square	0.037
Standard error	0.599
Observations	34

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.809	0.808	2.257	0.143
Residual	32	11.466	0.358		
Total	33	12.275			

	Coefficients	Standard error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1.582	0.372	4.252	0.0001	0.824	2.339
Access to media platforms	0.319	0.213	1.502	0.142	−0.114	0.753

3.10. Correlation between corn farmers' awareness of aflatoxin dangers and adoption of aflatoxin mitigation protocols

Table 9. **Correlation between corn farmers' awareness of aflatoxin dangers and adoption of aflatoxin mitigation protocols**

Таблица 9. **Корреляция между осведомленностью фермеров, выращивающих кукурузу, об опасности афлатоксина, и их принятием протоколов контроля афлатоксина**

Regression statistics	
Multiple R	0.829
R square	0.687
Adjusted R square	0.677
Standard error	0.346
Observations	34

ANOVA

	df	SS	MS	F	Significance F
Regression	1	8.427	8.427	70.084	1.449E-09
Residual	32	3.848	0.12		
Total	33	12.275			

	Coefficients	Standard error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.333	0.222	1.503	0.143	−0.118	0.784
Awareness of Aflatoxin danger	0.919	0.109	8.372	1.449E-09	0.695	1.142

There is a strong positive correlation between awareness of aflatoxin dangers and the adoption of mitigation protocols, and this correlation is statistically significant (Table 9). Higher awareness levels significantly predict higher adoption rates.

This strongly supports the second and third objectives. It highlights that increasing awareness of aflatoxin dangers is crucial for enhancing the adoption of aflatoxin mitigation protocols.

Health Belief Model constructs of perceived severity and benefits are validated here, showing that higher awareness translates into practical actions. While the Social Cognitive Theory emphasis on observational learning and self-efficacy also aligns with these findings, suggesting that the farmers' confidence and observational experiences facilitate their adoption behaviors.

3.11. Synthesis and emerging patterns

The analyses of Tables 5 through 9 reveal several critical patterns. First, there is weak impact of media access alone. General access to media platforms shows weak and non-significant correlations between awareness and adoption, highlighting the need for more direct, engaging forms of education and training. Second, the critical role of awareness: Tables 6 and 9 show strong, significant correlations between awareness (both of protocols and dangers) and adoption, underlining the importance of targeted awareness campaigns. Third, it is crucial to have effective engagement methods. Training and seminars, which offer interactive and observational learning opportunities, prove to be the most effective methods for raising awareness and promoting the adoption of mitigation protocols. Fourth, the validation of theoretical frameworks. The findings consistently validate the Health Belief Model and Social Cognitive Theory frameworks, emphasizing the importance of perceived severity, benefits, self-efficacy, and observational learning in driving awareness and adoption.

Given the empirical data from these tables, it supports the study's hypotheses and objectives. They underline the necessity of targeted, interactive educational strategies to enhance awareness and adoption of aflatoxin mitigation protocols. By grounding these findings in Health Belief Model and Social Cognitive Theory, the study provides a comprehensive theoretical framework that forms future interventions and contributes to the broader discourse on agricultural practices and food safety. The insights concluded from this analysis offer practical recommendations for enhancing the Aflatoxin Intervention Program and ensuring its effectiveness among corn farmers in Bukidnon, Northern Mindanao.

4. Discussion

The analysis of Tables 1 to 9 has unveiled several critical patterns and insights, each shedding light on different aspects of the Aflatoxin Intervention Program implemented by the Department of Agriculture Regional Field Office 10. These patterns not only provide empirical validation of our hypotheses but also offer a comprehensive understanding of the program's effectiveness and finding the areas for their improvement.

4.1. Pattern of awareness

One of the most striking patterns emerging from the analysis is the high level of awareness among corn farmers regarding both the dangers of aflatoxin and the mitigation protocols. Tables 1 and 2 collectively demonstrate that a significant majority of the farmers are either "Aware" or "Very Aware" of these critical aspects, with 73.32% aware of aflatoxin dangers and 80.47% aware of mitigation protocols. This suggests that the awareness campaigns and educational efforts by the Department of Agriculture Regional Field Office 10 have been relatively successful in distributing vital information about aflatoxin. However, the persistence of unawareness among 26.68% (dangers) and 19.54% (protocols) of farmers indicates gaps that require further attention.

This finding aligns with a study by Bacani [18] in Nueva Vizcaya, Philippines, which reported a high level of awareness among corn farmers trained in Good Agricultural Practices (GAP) for aflatoxin prevention. Yet, Bacani warned that such awareness might be limited to trained farmers, this nuance echoed in our results where untrained farmers could be accounted for the "Unaware" group. Conversely, broader studies, such as those by Rustia et al. [26] and Balendres et al. [27], advocate for intensified awareness campaigns, suggesting that awareness remains inconsistent across regions and demographics. On a global scale, recent research by Gichohi-Wainaina et al. [28] in Malawi and Udomkun et al. [29] in Congo reveals persistent unawareness linked to higher aflatoxin contamination, thus substantiating the need for sustained sensitization, training, and monitoring systems.

The high awareness levels support the research hypothesis that effective educational interventions enhance the farmers' understanding of aflatoxin risks and mitigation strategies, as posited by the Health Belief Model (HBM) and Social Cognitive Theory (SCT). The 73.32% awareness of dangers aligns with HBM's emphasis on perceived severity and susceptibility, suggesting that farmers recognize aflatoxin as a significant threat. Similarly, the 80.47% awareness of protocols reflects SCT's focus on observational learning and self-efficacy, indicating that farmers are absorbing actionable knowledge from peers and experts. However, the "Unaware" minority challenges the universality of hypothesis, hinting at existence of barriers such as obstacles to access to training or socioeconomic factors that future studies should explore.

Our results partially align with Bacani [18], who found 85% awareness among trained Filipino farmers, a higher figure than our 73.32% for dangers and 80.47% for protocols, possibly due to their focus on a trained groups. In contrast, Gichohi-Wainaina et al. [28] reported only 45% awareness in Malawi, attributing lower levels to limited extension services — suggesting that the higher figures in Bukidnon reflect stronger regional efforts on raising awareness. Udomkun et al. [29] found a 85% awareness rate of Aflatoxin in Congo but majority were not aware of its risks to human health, linking unawareness to cultural practices and inadequate access to information, a disparity that underscores the effectiveness of our localized campaigns. Meanwhile, a 2022 study by Gachara et al. [30] in Kenya reported 61% awareness, but highlighted poor postharvest protocol adoption, a potential concern for our farmers that merits further investigation.

These findings give ground to conclusions about the corn-farming communities in regions with active agricultural extension services, suggesting that structured education can elevate awareness. However, the 19.54% — 26.68% unawareness rate indicates that universal awareness is not yet achieved, possibly due to variations in training access, insufficient literacy, or resources availability. This pattern may extend to other aflatoxin-affected crops like peanuts or rice, where similar educational frameworks could yield comparable outcomes.

Practically, these results advocate for intensifying the existing awareness campaigns with targeted interventions for the "Unaware" group. Customized workshops, mobile-based education apps, and peer-led demonstrations could fill knowledge gaps, leveraging SCT's observational learning principles. Agricultural agencies could also integrate awareness metrics into monitoring systems to track progress and identify risk-exposed subgroups, thus enhancing policy effectiveness.

Future research should investigate why 19.54% — 26.68% of the farmers remain unaware, exploring factors like geographic isolation, education levels, or cultural beliefs. Comparative studies across regions could clarify the role of extension services versus community networks in awareness distribution. Additionally, longitudinal studies assessing whether high awareness translates to protocol adoption — echoing Gachara et al. [30] — would strengthen the link between knowledge and behavior, refining HBM and SCT applications in agricultural products health.

4.2. Mitigation protocol awareness

The data from Table 2 reveals that 80.47% of farmers are either "Aware" (52.45%) or "Very Aware" (28.02%) of aflatoxin mitigation protocols, with only 19.54% remaining "Unaware". This high awareness level suggests that the applied communication strategies — like including data extension services, workshops, and community outreach by the Department of Agriculture Regional Field Office 10 — are effective in distributing actionable knowledge. This finding aligns with the principles of Social Cognitive Theory (SCT), which emphasizes the role of social influences, observational learning, and self-efficacy in shaping awareness and behavior. The substantial awareness rate underscores the importance of peer learning and community-based education, where farmers are more inclined to observe and adopt mitigation practices modeled by trained peers or agricultural experts. Furthermore, the data supports the notion that awareness of aflatoxin dangers (73.32% from Table 1) may correlate with awareness of mitigation protocols, as the farmers who perceive the risk are more inclined to seek preventive solutions.

The 80.47% awareness of mitigation protocols supports the research hypothesis that effective educational interventions enhance farmers' understanding of aflatoxin management strategies, a premise rooted in SCT. The high awareness reflects successful knowledge transfer through social networks and observational learning, being the key SCT components. This also suggests that farmers' self-efficacy — the belief in their ability to implement protocols — may be bolstered by accessible, community-driven education. However, the 19.54% "Unaware" segment indicates that the hypothesis does not fully work for all farmers, pointing to potential barriers such as limited access to training or impeded informational channels which issue require further exploration.

This result aligns closely with findings from Bacani [18] in the Philippines, where around 76% of trained corn farmers demonstrated awareness of aflatoxin prevention protocols. The slight difference (76% vs. 82%) may reflect variations in sample size or training intensity, but both studies highlight the efficacy of targeted education. Similarly, Udomkun et al. [29] in Nigeria reported that 65% of farmers aware of aflatoxin dangers also knew preventive measures, a lower figure than ours, possibly due to less comprehensive data extension services. Meanwhile, Jallow et al. [31] in the Gambia noted a relatively low (49%) awareness of the farmers of aflatoxin, where only 58% knew mitigation strategies, thus proving the link between risk awareness and protocol knowledge but the share 80.47% in Bukidnon exceeds their outcomes, likely due to more effective community engagement.

These findings can be generalized to smallholder farming communities in tropical regions where aflatoxin is a prevalent concern and extension services are active. The 80.47% awareness suggests that structured, socially reinforced education can achieve broad reach, potentially applicable to the farmers who grow other crops like peanuts or sorghum exposed to similar contamination risks. However, the 19.54% unawareness rate cautions against overgeneralization, as it may reflect context-specific challenges such as rural isolation or educational disparities.

Practically, these results advocate for scaling community-based education models that leverage peer influence and observational learning, as per SCT. Agricultural agencies could develop mobile training units or digital platforms (e. g., SMS alerts or apps) to reach the 19.54% "Unaware" farmers, enhancing accessibility. Integrating protocol awareness into existing farmer cooperatives could further amplify peer-to-peer distribution, while regular assessments could ensure sustained knowledge memorizing and identify the areas needing improvement.

Future studies should investigate the 19.54% unawareness rate, exploring factors like geographic barriers, illiteracy levels, or trust in information sources. Research could also examine whether high protocol awareness converts to actual adoption, a gap noted by Bacani [18], with the help of longitudinal studies to track behavior change. Comparative analyses across regions with varying intervention intensities could refine SCT's application in agricultural settings, while exploring the role of digital tools in awareness campaigns offers a modern research pathway.

4.3. Adoption of mitigation practices

The data from Table 3 highlights a comprehensive adoption rate of aflatoxin mitigation protocols among the farmers, with "Early Adopters" (30.59%) and "Mainstream Adopters" (51.00%) collectively comprising 81.59% of respondents, while "Late Adopters" account for 18.41%. This high adoption rate underlines the practical impact of awareness and educational programs implemented by the Department of Agriculture Regional Field Office 10. It strongly supports Hypothesis 3, which assumes that heightened awareness leads to the adoption of aflatoxin mitigation practices. The Health Belief Model (HBM) provides a theoretical approach for this outcome, suggesting that the farmers perceive significant benefits — such as reduced crop contamination and improved health outcomes — from adopting these practices, while perceiving low entry barriers, such as cost or complexity of implementation, due to effective education and support systems.

The 81.59% adoption rate validates Hypothesis 3, illustrating a clear link between awareness (80.47% from Table 2) and behavioral change, as predicted by HBM. The model's structure of perceived benefits (e. g., safer yields) and low entry perceived barriers (e. g., accessible training) appear to drive this conversion from knowledge to action. The "Early Adopters" (30.59%) likely represent the farmers with higher self-efficacy and risk perception, quickly embracing the protocols, while "Mainstream Adopters" (51.00%) follow the pattern as social norms solidify — thus aligning with distribution of innovation theory alongside HBM. However, the 18.41% "Late Adopters" suggest that adoption is not universal, potentially due to impediments barriers or insufficient motivation, that requires further investigation.

This adoption rate aligns with findings from Bacani [18] in the Philippines, where 76% of aware corn farmers adopted Good Agricultural Practices (GAP) for aflatoxin control, closely mirroring 81.59% in Bukidnon. The slight difference may stem from our broader sampling in Bukidnon versus their focusing on trained farmers only. In contrast, Gachara et al. [30] in Kenya reported a low adoption rate among aware farmers, attributing the gap to resource scarcity and poor infrastructure — suggesting that Bukidnon higher rate reflects better support systems.

These results can be generalized to smallholder farming communities in regions with active agricultural extension services and aflatoxin risks, such as Southeast Asia or Sub-Saharan Africa. The 81.59% adoption rate suggests that well-implemented awareness campaigns, paired with accessible resources, can drive widespread practice uptake across similar agroecological zones. However, the 18.41% "Late Adopters" indicate that socio-economic or cultural factors may limit universality, thus necessitating context-specific adaptations.

Practically, these findings claim for intensifying the educational programs with hands-on demonstrations and subsidies to convert "Late Adopters" into mainstream users, leveraging HBM's focus on reducing barriers. Agricultural agencies could establish model farms showcasing mitigation benefits to enhance perceived efficacy, while peer-led training within community cooperatives could accelerate adoption among the hesitant farmers. Monitoring systems tracking adoption rates over time could also inform policy adjustments, ensuring long-term sustainability.

Future research should explore why 18.41% of farmers remain "Late Adopters," examining the barriers such as cost, access to materials, or trust in protocols. Longitudinal studies could assess whether adoption persists or wanes. Comparative analyses across regions with differing intervention models could refine HBM's application, while investigating the role of digital tools (e. g., apps for protocol guidance) offers a modern research frontier. Additionally, exploring the economic impact of adoption — such as harvest yield improvements or better market access — could strengthen the case for scaling these practices.

4.4. Effectiveness of media platforms

The analysis of Table 4 provides valuable insights into the effectiveness of various media platforms in distributing aflatoxin-related information to the farmers under the Department of Agriculture Regional Field Office 10. Training and seminars lead as the most visited platform (20.0%), followed by brochures (14.5%) and video streaming sites (media platform 2) (13.1%). Other platforms, such as radio (11.7%), television (10.3%), the DA media platform 1 (9.7%), and the DA Website (9.0%), show lower engagement, with "Others" at 11.7%. This pattern highlights the farmers' preference for interactive, detailed, and accessible learning methods over passive or less targeted media. Training and seminars likely offer hands-on guidance and peer interaction, while brochures provide tangible, concise references, and video streaming sites deliver visual, on-demand content. These findings suggest that future interventions should prioritize these high-impact formats to maximize engagement and awareness, supporting a multi-dimensional approach that integrates training with getting information from broader media like radio and TV, as recommended by Jallow et al. [31].

The prominence of training and seminars (20.0%) aligns with the research hypothesis that effective distribution channels enhance aflatoxin awareness and adoption, reflecting Social Cognitive Theory (SCT) principles of observational learning and self-efficacy. The farmers' preference for interactive platforms suggests these methods successfully reinforce knowledge retention and practical application. The lower engagement with digital platforms like the DA media platform 1 (9.7%) and Website (9.0%) may indicate the availability of hindering barriers such as limited internet access or digital illiteracy, partially challenging the hypothesis's universality and highlighting the need for customized methods of data delivery.

Future studies should investigate why digital platforms (DA media platform 1, Website) underperform (9.0% — 9.7%), should explore the hindering barriers like issues with connectivity, illiteracy, or content relevance. Research could compare the cost-effectiveness of seminars versus social media, building on Sandeep et al. [32] where 64% of respondents perceived information content on social media is good, to optimize resource allocation. Longitudinal studies assessing how media preferences evolve with digital adoption could refine strategies, while testing hybrid models (e. g., radio plus training) could enhance multi-dimensional approaches. Exploring farmer feedback on platform usability would further tailor interventions.

4.5. Weak impact of media access alone

Tables 5, 7, and 8 reveal that general access to media platforms alone has a weak and statistically non-significant effect on enhancing awareness of aflatoxin protocols ($R^2 = 0.066$, $p = 0.143$), awareness of aflatoxin dangers ($R^2 = 0.063$, $p = 0.151$), and adoption of aflatoxin mitigation protocols ($R^2 = 0.066$, $p = 0.143$). The low R^2 values (0.063–0.066) indicate that media access explains only about 6% of the variance in these outcomes, while the p-values above 0.05 confirm the lack of statistical significance. This suggests that while media access provides a necessary foundation for information distribution, it is insufficient on its own to substantially elevate awareness or drive adoption behaviors. The findings underline the need for more direct, engaging, and context-specific methods — such as training and seminars (noted in Table 4) — to complement exposure to passive media.

These results partially challenge the research hypothesis that media access significantly enhances awareness and adoption, as posited by frameworks like the Social Cognitive Theory (SCT) or Health Belief Model (HBM). The weak correlations (Multiple R = 0.252–0.257) suggest that mere availability of media platforms does not convert into effective learning or behavior change, contradicting assumptions that access alone fosters observational learning (SCT) or perceived benefits (HBM). Instead, the data imply that the quality, interactivity, and relevance of media content — or supplementary interventions — are critical mediators, only when media is paired with active engagement strategies.

4.6. Strong correlation between awareness and adoption

Tables 6 and 9 demonstrate strong, statistically significant correlations between awareness (of both aflatoxin protocols and dangers) and the adoption of mitigation protocols. Table 6 shows an exceptionally high correlation between awareness of protocols and adoption (Multiple R = 0.955, $R^2 = 0.913$, p = 1.584E-18), indicating that 91.3% of the variance in adoption is explained by protocol awareness. Similarly, Table 9 reveals a strong correlation between awareness of aflatoxin dangers and adoption (Multiple R = 0.829, $R^2 = 0.687$, p = 1.449E-09), accounting for 68.7% of the variance. These findings provide compelling empirical support for Hypotheses 1 and 3, which posit that higher awareness levels-whether of risks or preventive measures — convert into practical actions. This insight reinforces the critical role of targeted awareness campaigns that effectively communicate both the dangers of aflatoxin and the benefits of aflatoxin mitigation practices, aligning with the Health Belief Model (HBM) and Social Cognitive Theory (SCT).

The strong correlations ($R^2 = 0.913$ and 0.687) robustly validate Hypotheses 1 and 3, confirming that awareness is a key driver of adoption behavior. The near-perfect correlation in Table 6 ($R^2 = 0.913$) suggests that understanding aflatoxin mitigation protocols directly empowers the farmers to act, reflecting HBM's emphasis on perceived benefits and SCT's focus on self-efficacy. The slightly lower but still substantial correlation in Table 9 ($R^2 = 0.687$) indicates that risk awareness (perceived severity and susceptibility, per HBM) also motivates adoption, though less comprehensively than protocol knowledge, possibly due to a need for actionable guidance. These results highlight that awareness campaigns succeed when they bridge knowledge and practice, supporting the study's theoretical framework.

4.7. Preference for interactive learning

The data from Table 4 reveals a clear preference for interactive learning methods among farmers, with training and seminars leading as the most visited media platform at 20.0%, significantly outpacing other options such as brochures (14.5%), video streaming sites (13.1%), radio (11.7%), television (10.3%), the DA media platform 1 (9.7%), and the DA Website (9.0%). This high engagement rate with training and seminars underscores farmers' inclination toward formats that offer direct interaction, opportunities to observe experts and peers, and hands-on guidance. These settings align with the Social Cognitive Theory (SCT), which emphasizes observational learning, modeling, and self-efficacy as drivers of behavior change. Farmers participating in these sessions likely gain confidence to adopt mitigation practices (as evidenced by the 81.59% adoption rate in Table 3), highlighting the pivotal role of interactive learning in converting awareness into action.

The 20.0% engagement with training and seminars may imply that effective distribution methods enhance awareness and adoption, with interactive platforms proving superior. SCT's focus on observational learning is evident, as the farmers are likely to model behaviors observed during training, while the hands-on in-kind training boosts self-efficacy — being the key to adopting complex protocols. The lower engagement with passive platforms (e. g., DA Website at 9.0%) suggests that static or less interactive media fail to inspire similar confidence or motivation, supporting the hypothesis that data delivery mode matters. This preference aligns with the study's broader findings of strong awareness-adoption correlations (Tables 6 and 9), where interactive learning likely underpins the knowledge-to-action pathway.

4.8. Validation of theoretical frameworks

The empirical patterns emerging from this study — i. e. spanning awareness (Tables 1, 2), adoption (Table 3), media effectiveness (Table 4), and regression analyses (Tables 5–9) — consistently validate the theoretical frameworks of the Health Belief Model (HBM) and Social Cognitive Theory (SCT). HBM posits that perceived severity (e. g., aflatoxin dangers) and benefits (e. g., aflatoxin mitigation protocols) drive awareness and adoption behaviors, while SCT emphasizes observational learning (e. g., via training) and self-efficacy (e. g., confidence to act) as key mechanisms. The data aligns robustly with these theories, offering a solid foundation for understanding the dynamics of aflatoxin management among corn farmers and reinforcing their applicability in agricultural health interventions.

The results strongly support the study's hypotheses. For Hypothesis 1 (awareness of dangers leads to adoption), Table 9 shows a significant correlation (R^2 = 0.687, p = 1.449E-09), reflecting HBM's premise that perceived severity (73.32% aware, Table 1) motivates action (81.59% adoption, Table 3). Hypothesis 3 (awareness of protocols drives adoption) is even more emphatically validated by Table 6 (R^2 = 0.913, p = 1.584E-18), aligning with HBM's perceived benefits and SCT's self-efficacy, as 80.47% protocol awareness (Table 2) converts to practice. The preference for training (20.0%, Table 4) and weak media access impact (R^2 = 0.063–0.066, Tables 5, 7, 8) further support SCT's observational learning, as interactive methods outperform passive exposure to information. These alignments confirm that HBM and SCT effectively explain the awareness-adoption nexus, though the 19.54% — 26.68% unawareness (Tables 1, 2) and 18.41% late adopters (Table 3) suggest incomplete spreading of information, thus tempering universality.

4.9. Implications for the aflatoxin intervention program

The insights from this analysis — spanning awareness (Tables 1, 2), adoption (Table 3), media effectiveness (Table 4), and regression analyses (Tables 5–9) — carry significant implications for the Aflatoxin Intervention Program under the Department of Agriculture Regional Field Office 10. The high awareness levels (73.32% for dangers, Table 1; 80.47% for protocols, Table 2) and adoption rates (81.59%, Table 3) suggest that the program's outreach and educational efforts have been highly effective, particularly through interactive channels like training and seminars (20.0%, Table 4). However, the weak impact of general media access (R^2 = 0.063–0.066, p > 0.05, Tables 5, 7, 8) underlines a critical limitation, highlighting the need for more targeted, engaging, and context-specific communication strategies to complement broad media distribution.

The high awareness and adoption rates confirm Hypotheses 1 and 3, which posit that awareness of aflatoxin dangers and protocols drives aflatoxin mitigation practice uptake, as evidenced by strong correlations (R^2 = 0.687, Table 9; R^2 = 0.913, Table 6). This suggests the program successfully leverages Health Belief Model (HBM) principles — perceived severity and benefits — and Social Cognitive Theory (SCT) mechanisms — observational learning and self-efficacy — via effective training (Table 4). Conversely, the negligible effect of media access challenges any hypothesis assuming that passive distribution of data is sufficient (e. g., implied in Section 4.5), indicating that success hinges on active engagement rather than availability alone. The 19.54% — 26.68% unawareness (Tables 1, 2) and 18.41% late adopters (Table 3) further suggest that while the program excels for most, gaps remain, thus necessitating for targeted approaches.

4.10. Future Interventions

The findings from this study — high awareness (73.32% for dangers, Table 1; 80.47% for protocols, Table 2), general adoption (81.59%, Table 3), and preference for training (20.0%, Table 4) — suggest that future interventions under the Aflatoxin Intervention Program should prioritize interactive and community-based learning methods, such as training and seminars, which have proven most effective. However, the 26.68% unaware of dangers and 19.54% unaware of protocols (Tables 1, 2), alongside 18.41% late adopters (Table 3), indicate a critical gap. Efforts must focus on reaching this approximately 20% of the farmers who remain uninformed or unengaged. A study on aflatoxin awareness in chili farming by Akintola et al. [16] highlights fragmented understanding of aflatoxin factors, mirroring our unawareness gaps and underlining the need for targeted educational programs and comprehensive public health initiatives. Customized interventions addressing specific barriers — such as lack of access, illiteracy, or trust — can bridge this gap and enhance overall program impact.

Future interventions should scale training and seminars (20.0%, Table 4), deploying mobile units to reach the 19.54% — 26.68% unaware (Tables 1, 2) and 18.41% late adopters (Table 3), leveraging SCT's observational learning. Tailored programs — e. g., simplified materials for low-literacy farmers or community-led sessions addressing the issue — could target this 20%, per HBM's focus on hindering barriers. Enhancing underused channels like video streaming (13.1%) with short, protocol-focused content or return to using the radio (11.7%) with farmer stories could complement training, addressing the weak media impact (Tables 5, 7, 8). Public health initiatives, as suggested by Akintola et al. [16], could integrate aflatoxin education into broader campaigns, this way ensuring comprehensive reach.

Research should investigate the 20% unawareness/adoption gap, exploring hindering barriers like geographic isolation or knowledge fragmentation, building on Akintola et al. [16]. Longitudinal studies could test if training sustains impact, while comparative analyses with digital-focused programs (e. g., Sandeep et al. [32]) could assess scalability. Qualitative studies on the farmer needs could refine tailoring, and testing hybrid models (e. g., seminars plus digital tools) could optimize outreach, addressing Udomkun et al. [29] multi-channeled supply of information. Exploring economic incentives for adoption could further enhance intervention design.

4.11. Comprehensive understanding

This analysis provides a nuanced and insightful understanding of the current state of aflatoxin management among corn farmers in Bukidnon, Philippines, under the Aflatoxin Intervention Program by the Department of Agriculture Regional Field Office 10. The study's empirical data are as follows — high awareness levels (73.32% for dangers, Table 1; 80.47% for protocols, Table 2), rational adoption rates (81.59%, Table 3), and strong awareness-adoption correlations (R^2 = 0.687–0.913, Tables 6, 9) — highlight the program's strengths in fostering knowledge and practice uptake through interactive methods like training and seminars (20.0%, Table 4). Simultaneously, it identifies critical areas for improvement, such as the persistent 19.54%–26.68% unawareness group (Tables 1, 2), 18.41% late adopters (Table 3), and the weak impact of general media access (R^2 = 0.063–0.066, p > 0.05, Tables 5, 7, 8). By integrating theoretical frameworks — Health Belief Model (HBM) and Social Cognitive Theory (SCT) — with these findings, the study offers the implementable recommendations to enhance the program's effectiveness, balancing its successes with strategies to cope with its shortcomings.

4.12. Contribution to the broader discourse

This study contributes significantly to the broader discourse on food safety and agricultural practices by offering a theoretically grounded and empirically comprehensive examination of the Aflatoxin Intervention Program in Bukidnon, Northern Mindanao, under the supervision of the Department of Agriculture Regional Field Office 10. The findings — drawn from Tables 1–9 — underline the pivotal role of targeted awareness campaigns, interactive learning methods (e. g., training at 20.0%, Table 4), and community-based education in facilitating the adoption of health-promoting behaviors, such as aflatoxin mitigation practices (81.59% adoption, Table 3). Anchored in the Health Belief Model (HBM) and Social Cognitive Theory (SCT), the analysis highlights how perceived severity, benefits, observational learning, and self-efficacy shape farmer responses, providing a model for addressing mycotoxin contamination globally. However, the persistent 19.54% — 26.68% unawareness (Tables 1, 2) and weak media access impact (R^2 = 0.063–0.066, Tables 5, 7, 8) reveal gaps not covered with this discourse, thus emphasizing the need for active engagement over mere exposure or demonstration.

4.13. Conceptual framework for enhanced aflatoxin management

The insights and patterns emerging from the analysis of Tables 1 to 9 provide a reliable foundation for developing a conceptual framework aimed at enhancing the Aflatoxin Intervention Program in Bukidnon, Northern Mindanao. The empirical data reveals high awareness levels

(73.32% for aflatoxin dangers, Table 1; 80.47% for aflatoxin mitigation protocols, Table 2) and their adoption rates (81.59%, Table 3), driven by interactive methods like training (20.0%, Table 4) and strong awareness-adoption correlations (R^2 = 0.687–0.913, Tables 6, 9). However, uncovered gaps persist: 19.54% — 26.68% remain unaware (Tables 1, 2), 18.41% are late adopters (Table 3), and general media access has a weak impact (R^2 = 0.063–0.066, Tables 5, 7, 8). By integrating these findings with the theoretical underpinnings of the Health Belief Model (HBM) and Social Cognitive Theory (SCT), the conceptual framework (Figure 1) systematically addresses the critical components of awareness, aflatoxin mitigation, and adoption behaviors among corn farmers.

This framework is designed to provide a structured, evidence-based approach for future interventions, emphasizing targeted awareness campaigns, effective media and communication strategies, and continuous feedback obtaining mechanisms. The strong correlations between awareness and adoption validate HBM's principles of perceived severity, susceptibility, benefits, and barriers, as well as SCT's focus on observational learning, self-efficacy, and social modeling. For instance, the preference for training (20.0%, Table 4) reflects SCT's observational learning, while high adoption (81.59%) aligns with HBM's perceived benefits. The framework leverages these insights to guide the Department of Agriculture Regional Field Office 10 in refining strategies, addressing the 20% unawareness gap, and ensuring sustained success in aflatoxin management, ultimately enhancing corn safety in Northern Mindanao.

4.14. Applying the conceptual framework

The conceptual framework (Figure 1) offers a structured road map for future interventions by the Department of Agriculture Regional Field Office 10, ensuring a holistic approach to managing aflatoxin contamination. It prioritizes five interconnected constructs: Awareness, Theoretical Underpinnings (HBM and SCT), Media and Communication Strategies, Adoption of Mitigation Protocols, and Outcomes and Feedback Mechanisms. By focusing on awareness (73.32% — 80.47%, Tables 1, 2), the framework ensures the farmers understand both the risks and solutions, targeting the 20% unawareness gap through targeted education. Leveraging effective communication strategies, such as training (20.0%, Table 4) over passive media (e. g., 9.7% for DA Facebook, Table 4), demonstrates more efficiency than the weak media impact (Tables 5, 7, 8), aligning with SCT's emphasis on engagement. The theoretical underpinnings guide intervention design — HBM informs risk messaging, while SCT shapes interactive learning — this way ensuring that the behavior change is both motivated and feasible.

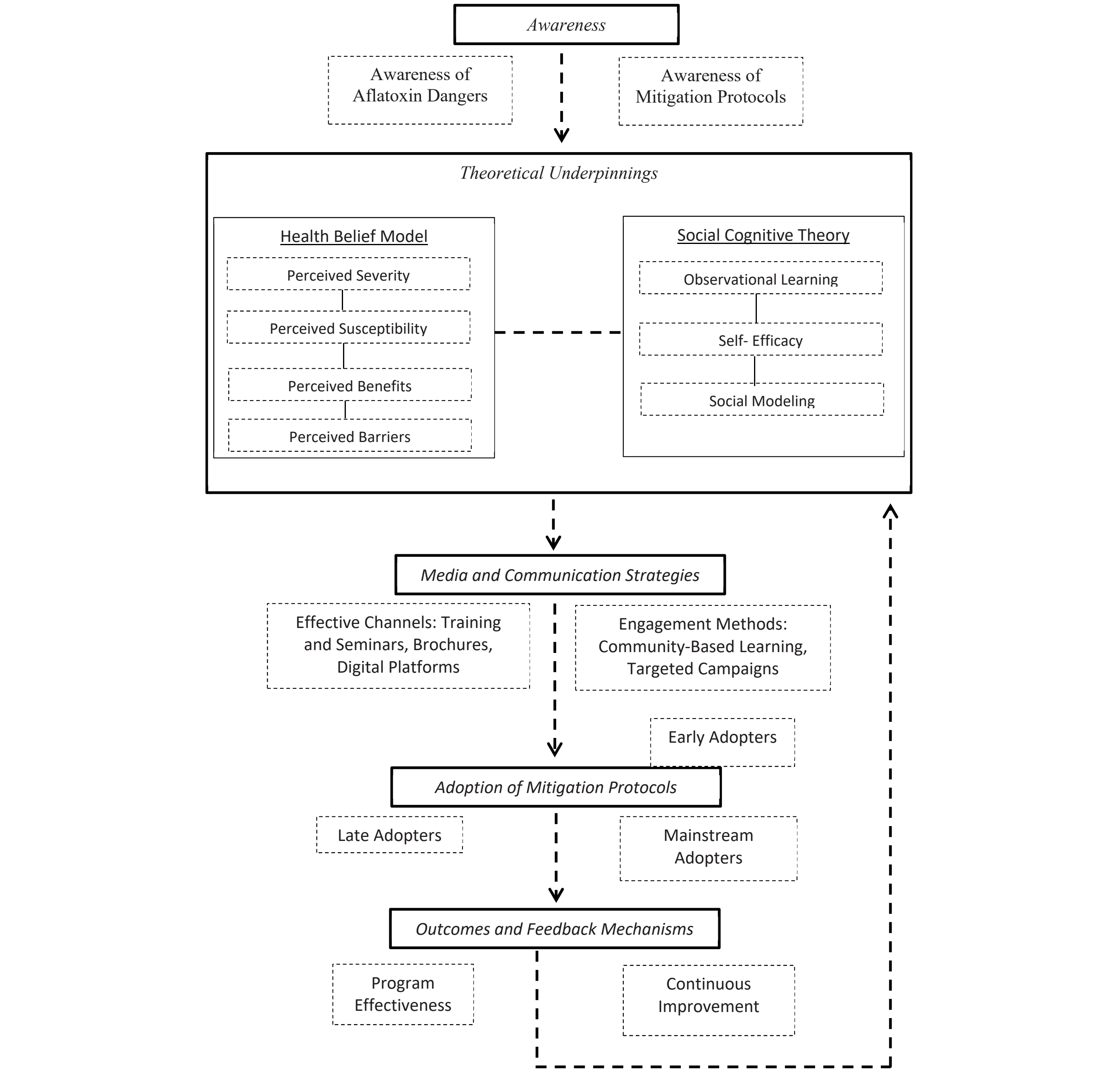

Figure 1. **Conceptual framework for enhanced aflatoxin management**
Рисунок 1. **Концептуальная схема для улучшенного контроля содержания афлатоксина**

The framework also emphasizes continuous feedback and improvement, enabling the program to adapt dynamically. For instance, assessing program effectiveness (e. g., adoption rates, Table 3) and gathering farmer feedback can refine strategies, ensuring they address evolving needs, such as reaching late adopters (18.41%, Table 3). This holistic approach not only enhances the program's impact on aflatoxin contamination management but also contributes to broader food safety goals by fostering sustainable practices among corn farmers in Bukidnon.

4.15. How does the conceptual framework work?

The conceptual framework (Figure 1) operates through five major constructs, each with sub-components, systematically addressing aflatoxin management by integrating empirical data and theoretical principles.

4.15.1. Awareness

This construct has two components:

- **Awareness of aflatoxin dangers**: With 73.32% of farmers aware (Table 1), this focuses on knowledge of health risks and contamination levels, emphasizing perceived severity (e. g., health impacts) and susceptibility (e. g., crop vulnerability), via HBM. The 26.68% unawareness highlights the need for intensified risk communication.
- **Awareness of aflatoxin mitigation protocols**: At 80.47% (Table 2), this ensures farmers know actionable strategies (e. g., proper drying, storage), driven by HBM's perceived benefits. The 19.54% unawareness underscores the need for broader distribution, particularly for late adopters (18.41%, Table 3).

14.15.2. Theoretical underpinnings

The framework's theoretical pillars are HBM and SCT, with interconnected components (as shown by the connecting line in Figure 1):

- **Health belief model (HBM)**:
  - *Perceived severity*: Farmers' recognition of aflatoxin's serious risks (73.32% aware, Table 1) drives action, as validated by the adoption correlation (R^2 = 0.687, Table 9).
  - *Perceived susceptibility*: Awareness of contamination likelihood motivates aflatoxin mitigation, though the 26.68% unaware (Table 1) suggest gaps in risk perception.
  - *Perceived benefits*: High protocol awareness (80.47%, Table 2) reflects belief in aflatoxin mitigation efficacy, strongly linked to adoption (R^2 = 0.913, Table 6).
  - *Perceived barriers*: The 18.41% late adopters (Table 3) indicate barriers like access or trust, which interventions must address. The internal lines in the HBM box (Figure 1) show how these constructs interplay — e. g., higher perceived severity increases perceived benefits, reducing barriers to adoption.
- **Social cognitive theory (SCT)**:
  - *Observational learning*: Training (20.0%, Table 4) enables farmers to learn from peers and experts, driving adoption (81.59%, Table 3).
  - *Self-efficacy*: High adoption reflects confidence in applying protocols, bolstered by interactive learning (Table 4).
  - *Social modeling*: Community leaders and peers in seminars model best practices, enhancing uptake, as seen in early adopters (30.59%, Table 3). The internal lines in the SCT box (Figure 1) illustrate their interplay — e. g., observational learning boosts self-efficacy, reinforced by social modeling.

The line connecting HBM and SCT in Figure 1 highlights their integration: HBM motivates through risk perception, while SCT facilitates action through learning and confidence, together forming a comprehensive theoretical foundation.

14.15.3. Media and communication strategies

This construct addresses distribution with two components:

- **Effective channels**: Training (20.0%), brochures (14.5%), and video streaming (13.1%, Table 4) outperform passive media (e. g., 9.7% for DA Facebook), aligning with SCT's engagement focus. The weak media access impact (R^2 = 0.063–0.066, Tables 5, 7, 8) substantiates the need for interactive channels.
- **Engagement methods**: Community-based learning and targeted campaigns, leveraging local leaders, foster supportive environments, as evidenced by training's success (Table 4).

14.15.4. Adoption of mitigation protocols

This construct categorizes adoption dynamics:

- **Early adopters** (30.59%, Table 3): Quick to implement protocols, likely due to high self-efficacy (SCT) and perceived benefits (HBM).
- **Mainstream adopters** (51.00%, Table 3): The majority, adopting after observing early success, reflecting social modeling (SCT).
- **Late adopters** (18.41%, Table 3): Require targeted interventions to overcome hindering barriers (HBM), such as issues with access or trust issues.

14.15.5. Outcomes and feedback mechanisms

This ensures program sustainability:

- **Program effectiveness**: High adoption (81.59%) reduces contamination, but the 20% unawareness gap (Tables 1, 2) indicates the areas subject for improvement.
- **Continuous improvement**: Feedback mechanisms (e. g., farmer surveys, adoption tracking) enable iterative refinement, addressing gaps like late adopters (Table 3).

The framework's flow — from awareness to adoption, supported by theory and communication, with feedback loops — ensures a dynamic, evidence-based approach to aflatoxin management.

14.15.6. Why is the conceptual framework important?

The conceptual framework provides a comprehensive, theoretically sound, and practically effective approach to enhancing the Aflatoxin Intervention Program. By focusing on critical components — awareness (Tables 1, 2), adoption (Table 3), and communication (Table 4) — it ensures the program reduces aflatoxin contamination while addressing gaps like the 20% unawareness (Tables 1, 2). Its integration of HBM and SCT bridges theoretical insights with empirical findings, validating their applicability (R^2 = 0.687–0.913, Tables 6, 9) and filling literature gaps, such as Akintola et al. [16] call for targeted education. The framework offers insights into communication efficacy — training's dominance (20.0%, Table 4) versus passive media's weakness (Tables 5, 7, 8) — and behavior drivers, advancing global food safety discourse.

For the Department of Agriculture, particularly Regional Field Office 10, the framework serves as a practical guide, identifying training and community-based methods as key to raising awareness (80.47% for protocols) and adoption (81.59%), per Sections 4.7 and 4.9. It ensures efficient resource allocation by prioritizing high-impact strategies (e. g., scaling seminars) and addressing the 18.41% late adopters (Table 3) with customized interventions. The emphasis on community leaders and peer educators fosters a supportive learning environment, enhancing reach and impact, as seen in SCT-driven training success (Section 4.7).

The framework's focus on continuous feedback mechanisms ensures adaptability, allowing the program to evolve along with the farmers' needs — e. g., refining digital strategies (13.1% video use, Table 4) to match Sandeep et al. [32] 39% success. This dynamic approach contrasts with static programs which saw low adoption rate due to poor follow-up, highlighting the framework's strength. Overall, the framework contributes to agricultural practices and food safety by offering a structured, evidence-based model for aflatoxin management in Bukidnon. It aligns with global findings (e. g., Gichohi-Wainaina et al. [28] and Gachara et al. [30]) while providing practical recommendations — scaling interactive learning, targeting the unaware group, and integrating feedback for sustainable success in Northern Mindanao and beyond.

5. Conclusion

The analysis of aflatoxin management among corn farmers in Bukidnon, Northern Mindanao, under the aegis of the Aflatoxin Intervention Program, conducted by the Department of Agriculture Regional Field Office 10, provides a comprehensive and empirically grounded understanding of awareness, adoption, and communication dynamics. The study's findings — high awareness levels (73.32% for dangers, Table 1; 80.47% for protocols, Table 2), wide adoption rates (81.59%, Table 3), and strong awareness-adoption correlations (R^2 = 0.687–0.913, Tables 6, 9) — demonstrate the program's effectiveness in leveraging interactive methods like training (20.0%, Table 4) and aligning with the Health Belief Model (HBM) and Social Cognitive Theory (SCT). These results prove the Hypotheses 1 and 3, confirming that awareness drives aflatoxin mitigation behaviors when supported by perceived severity, benefits, observational learning, and self-efficacy.

However, the analysis also reveals critical gaps: 19.54% — 26.68% of the farmers still remain unaware (Tables 1, 2), 18.41% are late adopters (Table 3), and general media access provides a weak impact (R^2 = 0.063 – 0.066, Tables 5, 7, 8). These findings underline the limitations of passive distribution and the need for targeted, engaging strategies. The proposed conceptual framework (Section 4.13–4.16) integrates these insights with HBM and SCT, offering a structured approach to enhance the program by coping with unawareness, optimizing communication, and ensuring continuous improvement. This study contributes to the global discourse on food safety by providing a replicable model for mycotoxin management, while identifying areas for clarification in order to ensure inclusivity and sustainability in Northern Mindanao's corn production.

6. Recommendations

6.1. Project level

At the project level, immediate actions should focus on enhancing the Aflatoxin Intervention Program's outreach to cover the 19.54%–26.68% unaware farmers (Tables 1, 2) and 18.41% late adopters (Table 3). First, it is feasible to deploy mobile training units to scale the successful seminar model (20.0%, Table 4), this way targeting remote areas with hands — on sessions that leverage peer modeling and expert guidance, aligning with SCT's observational learning. Second, develop customized educational materials — such as simplified brochures (14.5%, Table 4) or short, protocol-focused media platform 2 videos (13.1%, Table 4) — aimed to reach low-literacy or digitally challenged farmers, addressing HBM's perceived barriers. Third, establish pilot projects with community leaders to facilitate social modeling (SCT), encouraging early adopters (30.59%, Table 3) to mentor late adopters, ensuring a supportive learning environment. These efforts should include regular monitoring to assess impact, refining project design based on the farmers' feedback to maximize effectiveness.

6.2. Program level

At the program level, the Department of Agriculture Regional Field Office 10 should institutionalize a holistic strategy to sustain and scale the program's success. First, integrate aflatoxin education into broader public health and agricultural extension initiatives, building on the 81.59% adoption rate (Table 3) to address contamination across Northern Mindanao, as suggested by Akintola et al. [16]. Second, enhance insufficiently used media channels — radio (11.7%), television (10.3%), and digital platforms (9.7% — 13.1%, Table 4) with farmer-centric content (e. g., Q&A segments, offline-accessible videos) to overcome the weak media impact (Tables 5, 7, 8), aligning with HBM's perceived benefits focus. Third, it is necessary to establish a continuous feedback mechanism, involving the farmers' surveys and measures adoption tracking, to adapt strategies dynamically, targeting the 20% unaware group (Tables 1, 2). This should include partnerships with local cooperatives to reinforce community-based learning, ensuring long-term program resilience and scalability across the similar agroecological zones.

6.3. Direction of future studies

The synthesis of future research directions obtained from the enhancements suggests a multi-faceted approach to deepen the understanding and to improve aflatoxin management. First, it is required to investigate the 20% unawareness share and late adoption group (Tables 1–3), exploring the hindering barriers such as geographic isolation, issues with literacy, lack of trust, or knowledge fragmentation, basing on Akintola et al. [16] conclusions. Second, to conduct longitudinal studies to assess the sustainability of high awareness (80.47%) group and adoption (81.59%) group rates, evaluating whether interactive methods (e. g., training at 20.0%, Table 4) still maintain due impact over time. Third, it is necessary to perform comparative analyses with digital-focused interventions (e. g., Sandeep et al. [32], with 39% social media engagement) to integrate scalable technologies into the current framework, addressing the 9.7%-13.1% of digital uptake (Table 4). Fourth, it is feasible to conduct qualitative studies to explore the farmers' perceptions of HBM constructs (e. g., severity, benefits) and SCT mechanisms (e. g., self-efficacy, social modeling), and to clarify the intervention concept design. Finally, to test the hybrid communication models (e. g., seminars plus radio, per Jallow et al. [31]) in order to optimize the informational coverage, ensuring that the framework adapts to evolving needs and contributes to global food safety discourse.

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