

Beyond Fear and Trust: Invoking Anticipated Regret to Promote Biosecurity Measures among U.S. Swine Producers

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Abstract: Transboundary animal diseases pose significant threats to livestock systems and require strong producer engagement in biosecurity practices to ensure effective response. This study investigates how anticipated regret influences swine producers' intentions to adopt biosecurity measures during outbreak scenarios. Drawing on the extended Theory of Planned Behavior framework, we conducted a national survey to examine producers' decision-making under disease risk. Using a Partial Least Squares - Structural equation modeling we assess the relationships among attitudes, subjective norms, perceived behavioral control, and anticipated regret. Findings show that while traditional behavioral constructs remain significant, anticipated regret independently contributes to the prediction of biosecurity intention. Producers who expected to feel regret after failing to act reported stronger compliance intentions, suggesting that emotional foresight plays a critical role in biosecurity behavior. These results indicate that policies and communication strategies that appeal to both rational evaluation and emotional anticipation may more effectively promote compliance. By capturing the psychological underpinnings of producer behavior, this research offers new insight into how behavioral science can inform livestock disease preparedness and crisis communication efforts.

Keywords — Biosecurity, Anticipated regret, partial least squares – structural equation model

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INTRODUCTION

Transboundary animal diseases such as African Swine Fever, Classical Swine Fever, and Foot and Mouth Disease continue to disrupt livestock production systems and global trade. These outbreaks place enormous strain on food systems, exacerbate rural poverty, and undermine progress toward achieving the sustainable development goals [1]. In the United States, the

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response to such events is guided by a set of federal and state level protocols that include quarantine, movement restrictions, depopulation, compensations, and indemnity payments. However, the effectiveness of these interventions often depends on the voluntary cooperation of livestock producers, as they face ambiguous choices driven by uncertainty, incomplete information, and incompatible economic incentives [2].

While indemnity programs aim to reduce the financial burden of disease outbreaks, they can produce unintended effects when perceived as lacking fairness or alignment with actual losses. Producers may hesitate to invest in prevention if they believe compensation will be guaranteed regardless of their actions [3]. At the same time, reporting disease may trigger substantial economic losses and social consequences, further complicating compliance [4]. These trade-offs point to the need for a deeper understanding of how livestock producers assess risk and make decisions during periods of uncertainty and potential crisis. Traditional economic models struggle to fully capture these decision dynamics, especially when emotional, cognitive, and social drivers influence producer behavior [2].

Recent studies suggest that forward-looking emotions like anticipated regret can shape precautionary decisions. Anticipated regret thus refers to the emotional discomfort people expect to feel if they make a decision that leads to an undesirable outcome [5, 6]. For livestock producers, the potential regret of not adopting preventive measures can be a powerful motivator, especially when the consequences of inaction are severe or irreversible. Conversely, regret may also arise from investing in protection that ultimately proves unnecessary, leading producers to question the value of their preventive efforts. These contrasting expectations influence precautionary behavior in ways that conventional models do not fully explain. Emotional responses, trust in authorities, and perceptions of fairness in disease control policies all play a role in shaping these decisions [2].

This study assesses how anticipated regret interacts with attitudes, perceived norms, and behavioral control to shape biosecurity intentions among U.S. swine producers. Using the extended Theory of Planned Behavior as a guiding framework, we analyzed behavioral survey data to examine factors influencing biosecurity intentions. Through this analysis, we assess the role of affective and cognitive constructs in shaping producers' adoption of protective measures and evaluate how crisis communication strategies can activate these psychological mechanisms to enhance disease preparedness.

LITERATURE REVIEW

The United States holds a central role in global pork markets as both a major producer and consumer, making its livestock sector particularly vulnerable to TADs like ASF [7]. In 2023, the U.S. ranked as the world's third largest pork exporter, a position it has maintained since becoming a net exporter in 1995. Industry data show consistent growth, with pork exports expanding at an average annual rate of 2.1 percent between 2014 and 2023, reaching a total export value of \$8.17 billion. This economic significance means that disease outbreaks threaten not just domestic production but also international trade relationships. While biosecurity measures offer protection, their effectiveness depends entirely on producer compliance, which has proven difficult to secure through conventional policy approaches [8].

Traditional outbreak management strategies have focused on economic incentives, particularly through indemnity programs that compensate producers for livestock losses during disease containment efforts [2, 3]. These programs serve dual purposes: they provide financial relief during crises while theoretically encouraging preventive investments in biosecurity. However, numerous studies demonstrate that such programs frequently fail to achieve their intended outcomes [2, 3, 4, 8, 9]. Producers often respond to these incentives in unexpected ways that contradict standard economic predictions. A key issue emerges when producers perceive compensation as guaranteed regardless of their preventive actions, leading some to underinvest in biosecurity while others with strong existing practices feel penalized for their efforts [3, 4]. These persistent challenges reveal fundamental limitations in relying solely on economic models to explain and influence biosecurity behavior [2, 3].

Recent research has begun addressing these limitations by incorporating psychological factors into models of agricultural decision making [2, 7, 8]. One particularly promising area of investigation focuses on anticipated regret, the emotional distress associated with imagining negative outcomes from one's choices. In the context of livestock production, farmers may experience regret about two potential scenarios: failing to implement biosecurity measures if an outbreak occurs or investing in unnecessary precautions if no disease emerges. This dual possibility creates complex decision dynamics that extend beyond cost benefit analysis. Understanding these behavioral dimensions helps explain why producers might resist or inconsistently adopt biosecurity measures even when facing economic incentives.

These insights suggest new approaches to crisis communication and policy design. Conventional strategies typically emphasize either information about risks or financial considerations. However, emerging evidence shows that communication framed to highlight potential regret may prove more effective at motivating preventive action [5, 6]. When messages encourage producers to imagine the consequences of low biosecurity efforts, including financial losses, reputational damage, and emotional distress, they are more likely to adopt protective measures. Incorporating these behavioral insights into outbreak preparedness programs could help align policy objectives with actual producer behavior, potentially reducing the moral hazard problem in disease transmission risks.

METHODS OR PROCEDURES

We conducted a survey of U.S. swine producers between June and October 2023 to assess how anticipated regret influences intentions to adopt biosecurity measures. We employed a purposive sampling approach by distributing the survey through state extension

networks and producer association listservs, targeting swine producers actively engaged in the industry. The survey instrument consisted of two core components. The first was a behavioral questionnaire that collected data on producers' attitudes, perceived social norms, and perceived behavioral control regarding biosecurity adoption, following constructs outlined in the extended Theory of Planned Behavior. In addition, participants were asked to rate their anticipated regret for both adopting and not adopting specific biosecurity measures under hypothetical outbreak scenarios. The second component consisted of the demographic profile of the producers. This design allowed us to capture the trade-offs producers make when faced with uncertain disease threats and policy responses. In total, 130 swine producers responded to the survey, of whom 96 provided complete responses suitable for analysis. To examine the relationships between behavioral constructs and intention to adopt biosecurity practices, we employed partial least squares structural equation modeling (PLS-SEM). This approach is well suited for modeling complex relationships between latent variables, particularly in cases with moderate sample sizes and non-normal data distributions [9]. The measurement model included both reflective and formative constructs, with psychometric properties evaluated according to established thresholds for convergent validity, internal consistency, and discriminant validity. The structural model was used to estimate direct pathways in changing behavior. All analyses were conducted using R (version 4.3) with the SMinR package.

DISCUSSION

This study applies an extended Theory of Planned Behavior to better understand swine producers' biosecurity intentions during disease outbreaks. In line with established behavioral research, attitudes, subjective norms, and perceived behavioral control were found to significantly influence the intention to adopt preventive measures. However, anticipated regret, introduced as an affective and cognitive construct in the model, also emerged as a meaningful and independent predictor. The inclusion of regret-based reasoning enriches our understanding of compliance behavior by revealing how emotional and cognitive expectations influence decision-making in uncertain and high-stakes environments [6, 10].

Producers who held favorable evaluations of biosecurity measures, both in terms of how the measures aligned with their values and how effective they perceived them to be - were more likely to adoption biosecurity practices on their farms even in the face of incomplete information, uncertainty and incompatible incentives. These positive attitudes reflect a broader understanding of biosecurity not just as a regulatory requirement, but as a proactive management tool. Similarly, subjective norms played a significant role, indicating that producers are responsive to the expectations of peers, veterinarians, and agricultural advisors. This social dimension is often overlooked in technical biosecurity frameworks, yet it shapes how norms are communicated and enforced within producer communities [5, 6].

Figure 1: Extended theory of Planned Behavior.

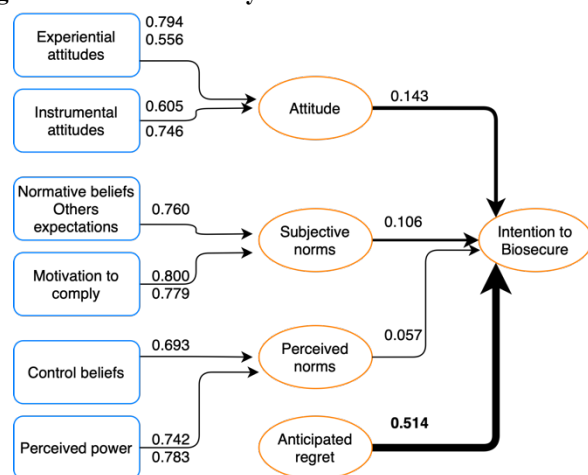
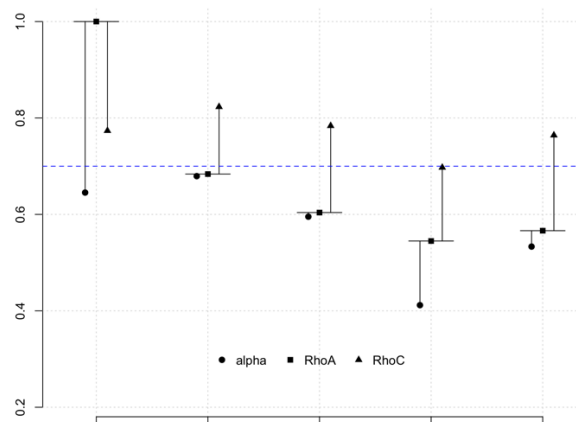


Figure 2 : Reliability Check of Composite Measures



The central contribution of this study lies in the role of anticipated regret. Producers who imagined future scenarios in which they failed to implement biosecurity and later suffered consequences expressed stronger behavioral intentions. Anticipated regret appears to act as an internal motivator that can either reinforce or override evaluations of risk and benefit. This aligns with findings from health behavior research, where regret has been shown to influence vaccination decisions and risk mitigation practices [5, 6, 10]. In this context, regret introduces a temporal and emotional frame to decision-making, prompting individuals to consider not only economics outcomes but also the personal consequences of inaction.

Perceived behavioral control also remained an important factor. Producers who felt they had the capacity, knowledge, and resources to implement biosecurity reported stronger intentions. However, this construct is often limited by external conditions, such as labor constraints or infrastructural gaps. In situations where producers are aware of biosecurity protocols but feel unable to act, perceived control may diminish even when attitudes and social norms are favorable [6]. Therefore, programs that aim to strengthen compliance must address both motivational and practical barriers.

These findings suggest that future biosecurity interventions should combine rational appeals with emotionally resonant messages. Communication strategies that help producers visualize the consequences of failing to act, including the economics and emotional impact of loss, may improve the salience and uptake of preventive practices. Rather than treating biosecurity as a technical checklist or compliance obligation, effective outreach efforts should reflect the behavioral complexity of producers as decision-makers. Supporting producers' confidence, reinforcing positive social norms, and framing disease

prevention in ways that evoke personal responsibility may all contribute to improved preparedness across the livestock sector. We further assess the internal consistency of the composite measures. The reliability plot shows that most constructs meet or exceed the conventional 0.70 threshold when assessed using composite reliability (RhoC) and Dijkstra–Henseler’s rho (RhoA), even where Cronbach’s alpha falls below this benchmark. This supports the internal consistency of the measurement model, particularly given the known conservatism of alpha in models with few indicators or complex loading structures.

CONCLUSION

This study highlights the value of integrating anticipated regret into behavioral models of livestock disease preparedness. While attitudes, social norms, and perceived control remain important predictors of biosecurity intention, the emotional and cognitive anticipation of future regret adds a critical psychological dimension to producer decision-making. Findings suggest that policy interventions and crisis communication efforts can be strengthened by acknowledging not only what producers know or can afford, but also how they feel about the consequences of inaction. Recognizing this complexity can support more effective approaches to disease control within the livestock sector.

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