# ADBCAP:
# A Human Approach to Improving Biosecurity

Scientia

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Foreign animal disease outbreaks in livestock systems have far-reaching economic, trade and food security implications. Biosecurity strategies can enhance the resilience of livestock production; however, understanding the behaviors of people involved in agriculture is critical – and more challenging. In a new approach, an innovative US-wide project is integrating social science, human decision making, economic and animal health perspectives to target disease prevention.

**The Scale of the Problem**

Agricultural receipts for US beef, pork and dairy products totaled at over 120 billion in 2018, and support around one million domestic jobs in the US. Given that over 25% of pork products and 12% of beef produced in the US are consumed abroad, any incident that triggers trade barriers to US animal products could have a rapid economic impact.

Recent disease outbreaks in the US illustrate how rapidly problems can escalate, and just how far-reaching the effects can be. One prominent example is Porcine Epidemic Diarrhea virus (PEDv), which was first detected in May of 2013. Just one year later, more than 6800 premises and 30 states had reported cases of PEDv. Prior to that, in 2003, one case of Bovine Spongiform Encephalopathy (BSE) in a cow in Washington State triggered the closure of export markets, which took seven years to recover to pre-BSE volumes. In the future, the livestock industry is also likely to experience the impacts of diseases that are not currently a problem, as the changing climate causes shifts in the movement of insect and arachnid species that carry or serve as vectors of disease.

With these impacts and future challenges in mind, the imperative to minimize losses from livestock disease has widespread implications for economic vitality, environmental health, and food security in local communities as well as around the world. The accidental or intentional introduction of a fast-moving disease such as PEDv, or vector-borne disease such as Rift Valley fever, requires a pre-planned national industry-wide response.

**A New Approach to Disease Prevention**

Besides the movement of animals themselves, the movement of people and equipment among livestock farms is a primary route of transmission for many highly contagious diseases. Mitigation strategies to tackle disease outbreaks go beyond ordinary preventative measures, commonly termed 'biosecurity'. Strategies such as

animal traceability, disease syndrome reporting and analysis, and risk-based herd health management are all promising ways to enhance the resilience of livestock production.

However, the adoption of biosecurity and additional disease mitigation strategies that benefit the greater good can prove challenging to implement at the level of the individual production unit. For biosecurity measures to be effective, managers and owners of

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livestock businesses must be willing to invest in biosecurity, and their workers must be willing to comply. The human aspects underlying the limited adoption and implementation of effective initiatives to reduce the impact of animal disease or pest incursions have not previously been well understood.

The need for a greater understanding of the reasons behind this lack of willingness to adopt or engage in biosecurity strategies was a key motivation underpinning the initiation of the Animal Disease Biosecurity Coordinated Agricultural Project (ADBCAP), funded by the US Department of Agriculture (USDA). Led by Professor Julie Smith from the University of Vermont, the ADBCAP is a collaborative project involving researchers from numerous universities throughout the US, as well as a wide range of stakeholders from within the livestock industry.

Integrating specialists from a number of different disciplines including veterinary, animal and social sciences, the ADBCAP team takes a multi-disciplinary approach to biosecurity. By taking a human behavioral approach rather than a disease-specific one, the team is able to assess the human aspect of disease prevention in livestock. Their goal is to understand the barriers and incentives to implementing biosecurity practices, in order to facilitate the development and adoption of practices and policies that reduce the impact of new, emerging or foreign animal diseases.

The team's three key areas of focus are: evaluating decision making and attitude to risk using simulation and modelling techniques; identifying the economic factors at play in adoption of biosecurity measures; and devising effective methods of communication to enhance biosecurity compliance. Many of the techniques used by the researchers are novel, such as the use of games to assess the dynamics of decision making, enabling them to determine how farmers and producers would react to disease or pest outbreaks, without exposing animals to new infectious threats.

This holistic approach has provided the team with an understanding of the vulnerabilities within the current system, enabling them to identify practices with the greatest likelihood of effectiveness. This means that focused attention can be given to effect change at these points through appropriate communication strategies. As part of their communication efforts, the ADBCAP team has created a suite of educational and outreach materials, which draw on the research results and lessons learned.

The project outcomes are intended to foster attitudes and behaviors that better protect animal health. They provide policy makers and key stakeholders with the resources and knowledge required to motivate increased adoption of biosecurity practices. This, in turn, will protect US livestock production and contribute towards tackling the food security challenge – both within the US and on a global scale.

# THE VIRTUAL FARM: SIMULATING RISK TO UNDERSTAND DECISION MAKING

The widespread adoption of biosecurity strategies on farms can prevent the spread of devastating livestock diseases, ultimately saving the US billions of dollars in economic damage. However, the factors influencing farm managers' decisions to invest in biosecurity have previously been poorly understood. To explore how farm workers might change their attitudes regarding investment and compliance with biosecurity measures, the ADBCAP team developed an innovative range of modelling and simulation techniques as part of an integrated decision support system.

**A 'Serious Game' Approach**

At an early stage in the ADBCAP, research team members met with industry stakeholders to better understand how farm workers make tactical and operational decisions around biosecurity. A key outcome of these meetings was an increased awareness that compliance with biosecurity protocols was a serious problem.

To study how biosecurity decisions are made in everyday on-farm scenarios and how workers could be encouraged to comply with protocols, the team decided to use simulated farm environments. Focusing on PEDv, they developed 'serious games' to help capture the operational compliance dimensions of livestock biosecurity systems and the tactical willingness to invest in biosecurity, and integrated the data within a wider digital decision support system model.

The first set of games, the 'Protocol Games', were designed to simulate the tactical decision of whether or when to invest in biosecurity practices on a farm. The second set of games, the 'Compliance Games', focused on how individual workers comply with expectations around biosecurity measures.

During the Protocol Games, participants were placed in charge of a swine production facility under the threat of a disease incursion. Similar to real world dynamics, participants were asked to make biosecurity investment decisions based on different disease or biosecurity communication strategies.

The Protocol Games sought to simulate biosecurity investment decisions made by owners or managers of production units. The scenarios that participants were exposed to were varied by changing the information provided about disease incidence and biosecurity strategy responses to the threat of disease.

During the Compliance Games, the ADBCAP team gave participants a series of tasks to complete within and outside of a barn. A 'dirty door' and 'clean door' were options for entering or leaving the barn, with points in the form of dollars being awarded for both completing the tasks and preventing infection incursions.

The Compliance Games attempted to simulate the types of decisions farm workers have to make on a daily basis. Scenarios varied by the way information about the threat of disease was communicated, either through the use of numbers, phrases or graphical displays. Additionally, the team varied how certain or confident they were with the threat of disease information.

**Not All Forms of Communication are Equal**

As might be expected, the results from the Protocol Games showed that willingness to invest in heightened biosecurity increased with increased


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awareness of disease incidence in the system. However, investment in biosecurity measures actually decreased with increased awareness of biosecurity practices in place at nearby facilities.

This suggests that policy makers aiming to enhance industry biosecurity need to think carefully about the messages being communicated; based on these results, the dissemination of information about biosecurity practices should not be encouraged. Conversely, policies and practices that encourage greater sharing of disease incidence information should have greatest benefit for protecting herd health.

The Compliance Games showed that increased situational uncertainty and increased risk were correlated with increases in compliance behavior. Increased uncertainty led to greater compliance. This may seem counterintuitive; however, when a probability is less certain, the potential for even higher rates of probability are there – leading to increased risk aversion.

The way in which messages were communicated also had a big impact on the level of compliance, with numeric, linguistic and graphical messages showing increasing efficacy respectively. The research team also found evidence for the concept of psychological distance – the impact of the passage of time and the influence of experience. Participants whose animals had recently become infected because of their choice to avoid using biosecurity were approximately twice as likely to use the shower facility compared to those who were nearing the end of the experiment and had not experienced an infection. This evidence for psychological distancing has profound educational implications for the industry because it reinforces the need for frequent reminders.

The team also found that graphical messages noting the inherent uncertainties rather than numeric best estimates of infection risk led to the most reliable compliance across the full range of game scenarios. These results provide an insight into the type of messages that should be most effective in nudging behavior towards more disease resilient systems. Messages delivered using graphical means to convey infection risk, including risk uncertainty, delivered with relatively high frequency to reduce the psychological distancing effect, have the potential to dramatically improve biosecurity compliance on livestock farms.

**An Integrated Decision Support System**

If using the lessons learned in the simulated farm environment can evoke a shift towards farm workers taking a more risk-averse approach, what could this actually mean for real-world disease incidence?

The ADBCAP team also used an Agent-Based Model (ABM) to determine the impact of increasing or decreasing risk-aversion on PEDv disease incidence. In this case, the team developed an ABM that was capable of incorporating the nuanced and sometimes non-rational behavior of humans into a realistic swine production environment at the scale of states such as North Carolina and Iowa. The team's ABM used both disease dynamics and algorithms to incorporate human decisions – integrating the results from the serious games – to see what patterns of disease transmission and impact may result from interventions that could impact the human decision-making process.

The researchers investigated the effects of shifting fractions of hog producers between risk tolerant and risk-averse positions. The results showed that if just 10% of producers change to a risk-averse position, a significant decrease in total disease incidence can be achieved. For steeper decreases in disease incidence, 37.5% of the model's hog producer population needed to be risk-averse.

The integration of ABMs and serious gaming into one common suite of decision support tools is a multi-level, multi-method approach to modeling the swine industry – providing industry leaders with increased situational awareness. The combined results from the serious games and modeling techniques provide insights into the links between risk attitude, decisions related to biosecurity and consequent spread of disease within a livestock production system. If the team's recommendations pertaining to the messages and methods of communication are adopted, they could have significant implications for the levels of biosecurity compliance within farming systems.

# INCENTIVIZING THE ADOPTION OF BIOSECURITY

Industry-wide biosecurity is only as good as its weakest point, so participation is key in providing continuity of business throughout the supply chain. With this in mind, ADBCAP researchers carried out surveys to better understand the economics of biosecurity implementation, and how stakeholders at all stages of production can be incentivized to invest in biosecurity.

**Surveying the Swine Industry**

Biosecurity is a key component of the US swine industry's Secure Pork Supply (SPS) Plan, designed to provide business continuity and protect operations in the event of disease outbreaks. No benchmarking of SPS Plan biosecurity implementation had previously been done. Therefore, in collaboration with state pork producer associations, ADBCAP researchers conducted a comprehensive multi-state survey of swine producers in 2017. Their objective was to determine how individuals in the industry make biosecurity investment decisions.

The results showed that the adoption of SPS Plan biosecurity varies and is affected by how feasible producers believe implementation of each biosecurity practice is on their operation. The surveys also revealed that producer demographics and producer risk attitudes affect biosecurity adoption – backing up the findings from the experimental games and modelling element of the wider ADBCAP. Results also revealed that adoption of biosecurity practices is overwhelmingly complementary – suggesting that one biosecurity practice likely increases the efficacy of another biosecurity practice.

The survey also asked questions about indemnity payments to find out what role expectations over compensation for losses as a result of disease outbreaks had on decisions surrounding biosecurity adoption. When the team analyzed the data from the 2017 swine producers survey, they found that producers had widely different views on what the likely government approach might be to indemnity payments, which in turn impacted their attitude to implementing biosecurity policies.

Producers expecting conditional indemnity payments, such as those distributed during the US highly pathogenic avian influenza outbreak of 2014–2015, where payments were made to those following recommended biosecurity strategies, tended to exert a more proactive biosecurity effort. The survey showed that if indemnity policy remains unconditional or unlikely to be mobilized and well-funded, then private, inner-industry factors such as livestock prices would become the main drivers of producer behavior. If market prices are independent of biosecurity, and a producer believes no indemnity funds will be mobilized, then investment will occur only if the difference in the private disease-reducing benefits from adoption is greater than the cost of adoption.

These findings highlight that biosecurity-conditional indemnity policies hold social value in aligning disease effort, and that clear communication of such policies could have a positive impact on the adoption of biosecurity measures – removing uncertainty as to what the government approach to indemnity payments might be in the event of disease outbreak.

**An Expert Opinion**

ADBCAP researchers also analyzed primary data collected from three surveys distributed to pork, beef cattle


and dairy industry experts in the US. The results showed that the experts surveyed believe that industry-wide biosecurity investment aimed at reducing major disease outbreaks would likely bring benefits primarily to downstream sectors in the supply chain (e.g., retailers or packers), whereas producers higher up the chain would bear most of the costs. Thus, the reason for insufficient biosecurity adoption may reflect the fact that producers lack economic incentives to further adopt biosecurity measures. One possible solution could be the creation of additional economic incentives to producers (e.g., cost-share programs); thereby, increasing national adoption that could benefit the whole supply chain.

Another important result from the expert surveys is that firms care about their own risk reduction as well as their neighbor's risk reduction. In addition to having altruistic motives, a producer might also recognize that what helps their neighbor's operation also helps their own operation.

In terms of communicating the risks of not complying with biosecurity measures, the survey results showed that producing more educational materials to explain disease risks and the benefits of risk-mitigating biosecurity measures was the least important factor for adopting new, additional biosecurity measures. A producer or neighbor having personally experienced a major livestock disease outbreak on their operation, a producer's view on their own likelihood of experiencing disease based on their current situation, and the producer's view on effectiveness in reducing major disease risks were found to be the most important factors.

**Incentivization Is Not Straightforward**

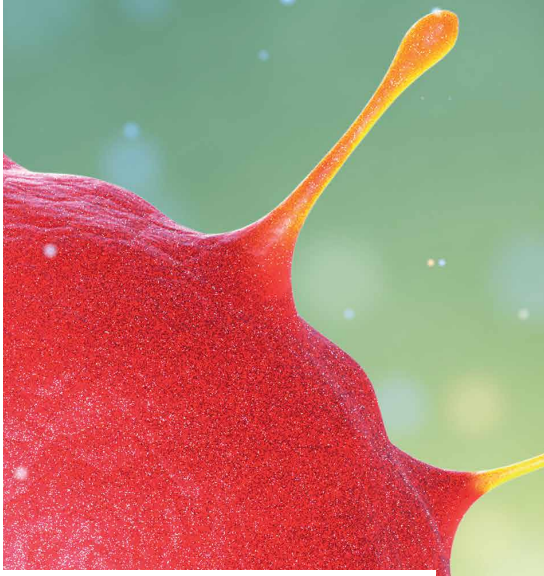
The ADBCAP researchers also looked at the role of packers and processors in the livestock biosecurity effort. They carried out a simple survey of North America's packers and processors to identify base perceptions, examine reactions to hypothetical major disease outbreak events and estimate willingness to pay producers for livestock biosecurity. Results showed that there was a willingness to pay a premium for livestock sourced from suppliers with third party verified biosecurity practices and therefore that there is likely a role for more direct packer-producer biosecurity incentives.

The results of the ADBCAP team's work also demonstrates that private and public considerations in managing biosecurity practices are different. The rationale behind the public decision is to take action so that social benefits outweigh social costs. However, what is socially optimal is not necessarily optimal for every individual within the supply chain. Producers deciding whether to invest will do so where their benefits outweigh their costs, and the decisions that they make will also be reflective of changes in livestock markets. Therefore, any incentivization policy must take into account both public and private considerations, and the fact that the driving factors behind decision making in both arenas will, by their nature, be different.

Overall, the various surveys and primary data collected by the researchers demonstrate that the application of biosecurity measures is a complicated matter that differs among operations due to a myriad of factors, and a one-size-fits-all educational and message targeting effort will likely not increase industry-wide biosecurity adoption. The insights this research provides regarding the complexities of biosecurity adoption are vitally important to both educators and policy makers.

# CRISIS COMMUNICATION: LEARNING FROM THE PEDV EXPERIENCE

The PEDv outbreak of 2013/2014 devastated the US swine population; however, without effective crisis communication, its impact could have been much greater. The ADBCAP team has studied how consistent messaging was achieved and how the lessons learned could help to reduce the impact of future disease outbreaks.



**A Deadly Outbreak**

At the height of the US Porcine Epidemic Diarrhoea Virus (PEDv) outbreak, the disease was killing as many as 100,000 piglets each week. This staggering loss of animals caused historically high prices for pork, with net annual losses in the region of $900–$1.8 billion to the US economy.

Creating an effective response to crises such as this PEDv outbreak requires a combination of research and communication. Research is essential for comprehending the nature of the disease, how it spreads, how it is best diagnosed and treated, and the best means for eradicating it and preventing its spread. The crisis communication challenge is to translate this highly complex research into instructional messages that are understandable, practical and compelling, so that producers are motivated to take appropriate action.

The rapid spread of PEDv during the first months of the outbreak, its lethal impact on farms and the novel and initially puzzling nature of the disease, made crisis communication very difficult. The challenge was addressed through the combined efforts of the National Pork Board, the National Pork Producer's Council, the American Association of Swine Veterinarians, local veterinarians and other swine experts. Combined, this group of specialists responded to the unprecedented threat of PEDv with an equally unprecedented research and communication outreach effort, helping to control the disease by the end of 2014.

**A Dominant Narrative**

To understand exactly how those involved in the crisis communication effort achieved such effective messaging around the PEDv outbreak, the ADBCAP team conducted interviews with 13 professionals who were directly responsible for responding to the crisis and sharing the narrative with stakeholders in pork-producing states.

The research team found that ultimately, the swine industry gained the upper hand on PEDv by making communication a central feature throughout the crisis. For this to occur, the diverse group of scientists, veterinarians and communication specialists involved had to collaborate rapidly to conduct research, translate the research into practice and develop consistent messages to compel the swine industry to use a series of intricate biosecurity practices. Their response was certainly speedy; initial essential research was completed, translated and communicated within 30 days.

Achieving consistency of communication is more difficult when multiple organisations are involved in designing and distributing the message, as was the case with the PEDv outbreak. The research team's interviews showed that the PEDv stakeholders recognised the need to work together strategically to develop convergent messaging and to determine where and how pre-established convergent beliefs needed to be altered. They then worked collaboratively to develop and distribute messages that effectively countered those pre-existing assumptions. The new convergent messages were delivered to all parties that could possibly contribute to the spread of PEDv – including producers, veterinarians, sale barns, truck drivers, agencies and farm workers.

In terms of communication methods, the interviewees explained that those involved were able to capitalise on a pre-established communications network that existed in the industry, to share their consistent and coordinated dominant narrative. This included weekly conference calls involving 30

*CREDIT: Joanna Cummings*

key members of the research and communication networks, the National Pork Board website, and producer and veterinarian magazines and journals. The crisis communicators' efforts were helped by the fact that these networks had already established themselves as credible information resources. Because they were already perceived as trustworthy by their target audiences, the new convergent messages were believed.

**Planning for the Future**

The analysis carried out by the University of Central Florida team shows that ultimately the success of future disease outbreak communication relies on the ability of a collaborative team of stakeholders to generate effective instructional messages for producers. The PEDv case also suggests that the swine industry team's willingness to let go of previously held assumptions, expedited their movement towards developing and then distributing an accurate dominant narrative.

The team also concluded that the cohesiveness of the industry and effective pre-crisis planning contributed to their success. In addition, participants emphasised how the adaptation of crisis plans that were already in place for other diseases were helpful in addressing PEDv. Crisis communicators were also undoubtedly helped by having abundant resources at their disposal, but the project team suggests that even where resources are lacking, collaborative alliances could be discussed as part of pre-crisis planning. Work done to foster inter-organisational collaboration and create a reliability culture in advance of a full-blown crisis provides opportunities to develop successful convergent messaging and the networks required to communicate effectively during a crisis.

Although all participants in the team's study praised the way research was completed rapidly and then proficiently translated into recommended actions, the respondents involved did note some weaknesses that could be addressed in future disease outbreaks. The team noted that recommendations for action merely told workers what to do, without providing other important educational details needed to encourage compliance. Several interviewees recommended that further attention be devoted to improving the instructional impact of message sharing to prevent unnecessary biosecurity breaches.

With growing global concerns about diseases in animal and human populations, this study provides the wider livestock industry with an important resource to help further develop and hone proactive crisis communication best practice strategies. Indeed, the research team concludes that any time spent now considering the challenges of maintaining biosecurity during a future crisis can be considered time well spent.

# Meet the researchers

**Dr Julia M. Smith**
**ADBCAP Director, University of Vermont**
Dr Julie Smith has a DVM and PhD from Cornell University, and is now a research associate professor in animal and veterinary sciences at the University of Vermont. Her key areas of focus include biosecurity and agricultural emergency management – making her well placed to direct the ADBCAP. Dr Smith has also conducted training for livestock producers and community members on the risks posed by a wide range of animal diseases.
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**Dr Scott C. Merrill**
**University of Vermont**
Dr Scott Merrill is a research assistant professor at the University of Vermont, focusing on the dynamics of change within pest-crop agroecosystems.
As part of the ADBCAP, Dr Merrill has used experimental gaming as a novel technique for collecting data to examine human decision making in agricultural systems. An important part of his research work involves the creation of applicable and predictive models to inform suggested best management practices.

**Dr Timothy L. Sellnow**
**University of Central Florida**
Dr Timothy Sellnow is a professor of strategic communication at the University of Central Florida. A key area of Dr Sellnow's research is pre-crisis planning and strategic communication for risk management and mitigation. His work as part of the ADBCAP has involved evaluating crisis communication strategies in the US livestock sector. Dr Sellnow has also conducted funded research for a range of US government agencies and served in an advisory role for the World Health Organisation.

**Dr Deanna Sellnow**
**University of Central Florida**
Dr Deanna Sellnow is a professor of strategic communication and assistant director of the Communication Department in the Nicholson School of Communication and Media at the University of Central Florida.
Dr Sellnow's key areas of research for the ADBCAP focus on crisis and instructional risk communication. She has also carried out funded research for a number of key governmental agencies including the Department of Homeland Security and the US Department of Agriculture.

**Dr Gabriela Bucini**
University of Vermont
Dr Gabriela Bucini has a PhD in ecosystem ecology and is now a post-doctoral researcher in the Plant and Soil Science Department at the University of Vermont. Her research for the ADBCAP has focused on developing agent-based models depicting the hog industry, including the integration of experimental gaming data into these models. Through this project, she seeks to reduce the impact of potential emergent diseases on herd health.

**Dr Glynn Tonsor**
Kansas State University
Dr Glynn Tonsor is a professor in the Department of Agricultural Economics at Kansas State University. Dr Tonsor comes from a swine farming background in Missouri and has broad research interests spanning issues throughout the meat supply chain. Through active research, outreach with industry and first-hand knowledge of livestock production, Dr Tonsor has gained economic expertise in an array of meat-livestock industry topics of global importance. His work for the ADBCAP focuses on the economics of risk perception and biosecurity.

**Dr Lee L. Schulz**
Iowa State University
Dr Lee Schulz holds a PhD in agricultural economics from Kansas State University, and is currently an associate professor in the Department of Economics at Iowa State University. Dr Schulz grew up on a diversified crop and livestock farm in central Wisconsin, and his integrated extension, research, and teaching program provides leadership in the study of critical problems facing the livestock industry. His work for the ADBCAP looks at the economics behind compliance with and implementation of biosecurity policies.

**Dr Christopher Koliba**
University of Vermont
Dr Christopher Koliba is a professor in the Community Development and Applied Economics Department at the University of Vermont. He is also the co-director of the Social Ecological Gaming and Simulation (SEGS) lab, which has played a key role in the modelling and simulation aspect of the ADBCAP. Dr Koliba's research interests include environmental governance, community resilience and network performance and accountability, with applications including water quality, food systems and emergency disaster response.

**Dr Asim Zia**
University of Vermont
Dr Asim Zia has a PhD in public policy and is a professor of Public Policy and Computer Science at the University of Vermont. He is co-director of the Social Ecological Gaming and Simulation (SEGS) lab, a fellow of the Gund Institute of Ecological Economics and a senior research fellow with the Earth System Governance Project. His research interests include complex systems modelling, computational policy analysis, coupled natural and human systems and social ecological systems.

**Dr Eric Clark**
University of Vermont
Dr Eric Clark received the first PhD in Complex Systems and Data Science from the University of Vermont. He is now a postdoctoral researcher in the Department of Plant and Soil Science and supports the Social Ecological Gaming and Simulation (SEGS) lab. Dr Clark plays a key role as a data scientist with the ADBCAP. His research interests include network theory, social contagion, computational linguistics, machine learning, evolutionary algorithms and complex systems.


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USDA United States Department of Agriculture National Institute of Food and Agriculture