Stakeholders' Perceptions of mRNA Vaccines in Beef Cattle: Exploring Acceptance, Concerns, and the Future of Beef Health Management

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DEDICATION

Dedicated to the United States beef industry.

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ABSTRACT

As of 2025, messenger RNA (mRNA) vaccines have not been approved for use in livestock. Despite this, the public has expressed concerns regarding the application of the vaccine in food-producing animals. In response to the public's escalating apprehensions, the purpose of this thesis was to gain insight on producers' and consumers' perceptions and behaviors regarding the use of mRNA vaccines in beef cattle. A qualitative study was conducted using the Theory of Planned Behavior to examine seven (n = 7) East Tennessee direct-to-consumer beef producers' behavioral intent to implement the vaccine on their operations in the future. In addition, a quantitative study was conducted through a national survey to evaluate beef consumers' (n = 519) behavior. Respondents in the survey were grouped into four categories of publics using the Situational Theory of Publics and the Five Publics Model Based on Knowledge and Involvement. The interviews conducted with the beef producers revealed that their weak attitudes, perceived negative subjective norms, and lack of perceived behavioral control would likely lead to a low behavioral intent to implement the mRNA vaccine on their operations in the future. The participants' weak attitudes were likely influenced by their low knowledge of the mRNA vaccine. The quantitative study revealed that respondents had an overall neutral stance in the areas of issue involvement, attitudes, risk perceptions, and purchasing intent related to the administration of mRNA vaccines in beef cattle. Additionally, knowledge of the novel vaccine technology was considerably low. Based on issue involvement and knowledge, respondents were grouped into four categories of publics: active, aware, aroused, and inactive. Based on the findings from both studies, a top priority for the animal agriculture industry should be educating consumers and producers about the mRNA vaccine technology and its current regulatory status

to enhance their knowledge. This research provides preliminary information on an emerging issue; therefore, future research should further examine stakeholders' perceptions of the mRNA vaccine in the livestock industry as the technology develops. To ensure the advancement of this disease-management tool, agriculture communicators will need to be proactive in their communication strategies.

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CHAPTER 1

INTRODUCTION

Overview

The purpose of this research was to examine stakeholders' perceptions of the use of the mRNA vaccine technology in the beef industry – specifically consumer perspectives and producer perspectives. The results from the two studies conducted in this research aim to provide agriculturalists with the information needed to be proactive on emerging issues surrounding the potential approval of mRNA vaccines in beef production. Chapter one provides a basic understanding of livestock vaccines, explores literature related to producers' decision-making processes for vaccine protocols, and examines consumer perceptions toward the beef industry. Furthermore, this chapter provides an introduction to the mRNA vaccine technology in livestock, public opinion surrounding mRNA vaccines, and proposed policy related to the mRNA vaccine for livestock that has appeared across the United States.

Vaccines in Livestock

The global population is expected to reach 9.7 billion people by the year 2050 (Food and Agriculture Organization of the United Nations [FAO], 2018), and animal proteins are a reliable food product that can meet the increasing nutrient demands of the growing population while protecting global food security (Henchion et al., 2017). Currently, approximately 34% of the global protein supply comes from animal proteins (FAO, n.d.). However, the global consumption of animal proteins is expected to increase by 14% by 2030 (Organisation for Economic Co-operation and Development & FAO, 2021). With this being said, animal production systems will need to meet the growing demands while producing safe and affordable food-animal products (Henchion et al., 2017).

Livestock production occurs in all 50 states in the United States (Ruth, 2023). In 2023, the United States produced 54.5 billion pounds of red meat, which includes beef, veal, pork, lamb and mutton (United States Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2024a). The livestock industry serves as a major contributor to the U.S. economy, generating $128 billion cash receipts in 2023, with cattle and calves accounting for 79% of this total (USDA NASS, 2024b). The impact of the U.S. livestock industry goes beyond supporting the American people, as they are a leading global exporter of red meat, exporting $37 billion of animal products in 2023 (Ufer, 2024).

Livestock vaccines have served an integral role in the U.S. livestock industry for many decades (Roth, 2011). Not only have vaccines been developed and implemented to protect animal health, but they also serve to protect human health (Roth, 2011). Livestock producers choose to implement vaccines on their operations to aid in the prevention of diseases that could compromise herd health, animal welfare, food production, and economic stability (Armstrong, 2023; Roth, 2011). Additionally, vaccine use on livestock operations have been promoted to reduce the need for antibiotics (Roth, 2011). While vaccines can promote the sustainability of the animal agriculture industry, they must continue to prove that they will remain safe, functional, and economically feasible for food-producing animals (Hoelzer et al., 2018).

Vaccine Regulation

To ensure that livestock vaccines remain safe for both animals and humans, livestock vaccines that are developed in or imported into the United States are regulated under the 1913 Virus-Serum-Toxin Act, which was amended by the 1985 Food Security Act (USDA Animal and Plant Health Inspection Service [APHIS], 2024). USDA APHIS, along with the help of the Center for Veterinary Biologics, are responsible for carrying out livestock vaccine regulations

(USDA APHIS, 2024). While the USDA APHIS carries out animal vaccine regulations, the Food and Drug Administration (FDA) oversees an extensive approval process for new animal drugs (United States Food and Drug Administration [FDA], 2020). The approval process begins with a drug sponsor conducting research studies to prove the safety and effectiveness of the drug (FDA, 2020). If the drug is to be used for food-producing animals, research must show that the drug is safe enough for people to eat food products produced from animals that have been treated with the drug (FDA, 2020).

After preliminary research on the proposed drug or vaccine has been conducted, an application with the research findings is submitted to the Center for Veterinary Medicine (CVM) (FDA, 2020). The drug is reviewed by a CVM committee that consists of veterinarians, animal scientists, biostatisticians, chemists, microbiologists, pharmacologists, and toxicologists who either approve or disapprove the animal drug (FDA, 2020). If the drug is approved by the committee, the drug can be sold for commercial use after the manufacturer receives a U.S. Veterinary Biologics Establishment License and a U.S. Veterinary Biologics Product License (FDA, 2020; USDA APHIS, 2024). While there are some cases that allow for an animal vaccine to be exempt from federal regulation, such as producing a vaccine for personal use or receiving approval from a state veterinary biologics program, all forms of drugs must go through this comprehensive process to be produced and distributed (USDA APHIS, 2024).

As stated above, vaccines serve as a management tool for livestock producers to avoid potential infections in their herd (Veterinary Preventive Medicine, n.d.). Vaccinations have been created for sheep, goats, swine, dairy cattle, and beef cattle to help protect against diseases that are common in each species (Veterinary Preventive Medicine, n.d.). For example, vaccines exist for clostridial and abortion diseases in small ruminants, porcine parvovirus (PPV) and influenza

in swine, and bovine viral diarrhea (BVD) and respiratory diseases in cattle (Veterinary Preventive Medicine, n.d.). The vaccine technology that has been used to prevent these common diseases will vary (Campos Krauer & Bittar, 2024).

Some common forms of vaccines that are used in animal production include attenuated, toxoid, subunit, conjugate, outer membrane vesicles (OMVs), heterologous, viral vector, ribonucleic acid (RNA), and the most novel category, messenger ribonucleic acid (mRNA; Campos Krauer & Bittar, 2024). While all of these technologies are used in animal vaccine production, modified-live vaccines and killed/inactivated vaccines are two of the most common categories of vaccine technologies that are used in livestock (Armstrong, 2023). Modified-live vaccines contain a weakened form of a virus, which mimics an infection from a particular disease and creates antibodies to protect the animal from that disease (Strickland, 2023). Conversely, killed/inactivated vaccines use a "dead" antigen that cannot replicate in the immune system, but still promotes an immune response (Strickland, 2023). The decision of which vaccine technology to use is at the discretion of the producer, but such decisions are typically made with advice from a veterinarian (Pavlik et al., 2014).

Producer Behaviors

Administering vaccines to livestock is a voluntary decision and varies from one producer to the next (Indiana Farm Bureau, 2023). Producers' vaccination decisions are often influenced by multiple factors, such as the type of operation, economic implications, animal welfare, presence of diseases, peer support, veterinary relationships, previous experiences, and drug efficacy (Ekakoro et al., 2019; Elbers et al., 2010). In addition, consumer perception and subjective norms, such as sources of information, can determine a producer's decision to vaccinate or not (Alarcon et al., 2014; Garforth, 2015; Huber-Eicher & Spring, 2008). Consumer

perceptions can determine how livestock producers market their product, making them an influential factor in vaccine decisions (Huber-Eicher & Spring, 2008).

Consumer Perceptions

According to a survey conducted by the Beef Research Council, 69% of American consumers indicated they eat beef at least once a week (Beef Research, 2022a). While consumer demand for beef remains strong, there are other factors that influence consumers' willingness to support the beef industry (Beef Research, 2022b). Two-thirds of consumers hold positive views toward beef products and approximately half of consumers hold positive views toward beef production (Beef Research, 2022a). Beef quality and eating experience are important aspects to consider for continued consumer satisfaction (Beef Research, 2022a); however, understanding consumers' knowledge, concerns, and trust in the beef industry are equally as important. Research has found that animal welfare, affordability, hormones, antibiotics, environmental impacts, and safety are among the top concerns of consumers who purchase beef products (Beef Research, 2022a; Moser, 2023).

Confidence in animal welfare conditions of beef cattle have been shown to be important to consumers as they often associate good animal welfare practices with safer food production (Ditlevsen et al., 2021; Fallon and Earley, 2008). Apart from animal welfare concerns, researchers have found that some consumers have begun to become fearful of vaccines, particularly when new or unfamiliar vaccines are introduced (Ditlevsen et al., 2021; Scudamore, 2007), which may be because consumers often associate uncertainty with risk (Ditlevsen et al., 2021). Some of consumers' apprehension has been linked to the perceived overuse of antibiotics in livestock animals and the involvement of biotechnologies (Ditlevsen et al., 2021). Speculation

regarding vaccine safety has caused consumers to seek food products that do not contain vaccine residues (Scudamore, 2007).

Consumer concerns regarding vaccine use in livestock can also emerge in the media when there is a disease outbreak, such as foot and mouth disease or avian influenza (Scudamore, 2007). Even if consumers see the importance of vaccinating animals to protect from zoonotic diseases, they often remain critical of the use of vaccines (Grunert, 2006). A study conducted in England found that only one-fourth of the research participants would eat meat from animals vaccinated against zoonosis (Zingg & Siegrist, 2012). With this information, and limited research being conducted on consumers' attitudes about eating products from food-producing animals that have been vaccinated (Scudamore, 2007), it is essential to determine what influences consumers' decisions to eat products from animals that have been administered vaccines, especially if a novel vaccine is used.

mRNA Vaccines

mRNA vaccines are one of the more innovative forms of vaccine technologies, in both human and animal medicine, and the public was first introduced to the mRNA vaccine during the COVID-19 pandemic (Le et al., 2022). The Centers for Disease Control and Prevention (CDC, 2024) defined a mRNA vaccine as, "A vaccine that uses mRNA to teach our cells how to make a protein – or even just a piece of a protein – that produces an immune response to a disease" (para. 97). mRNA is broken down rapidly in the bloodstream once it makes a protein, preventing it from entering the nucleus of a cell and binding to DNA (Mullane, 2021). Aside from COVID-19, mRNA vaccines hold great potential in human health to combat cancer, food and environmental allergies, genetic diseases, heart disease, and neurodevelopmental disorders (Penn

Medicine, n.d.). mRNA vaccines are not only showing a promising future in human medicine, but in animal medicine as well.

mRNA vaccines have been found to create a quicker and more effective immune response compared to traditional vaccines (Gote et al., 2023). Additionally, mRNA vaccines can be produced at a lower cost than other vaccines and are expected to become more cost-efficient as the technology advances (Gote et al., 2023). These factors can impact both human and animal health in the case of an outbreak of a zoonotic disease (Le et al., 2022). While other forms of vaccines require cell cultures for production, the mRNA vaccine does not, limiting the risk of contamination and enhancing its safety (Rosa et al., 2021).

Research has been conducted on mRNA vaccines in livestock for over a decade, yet there are no mRNA vaccines licensed for use for livestock in the United States as of 2025 (Strickland, 2023). A prescription vaccine that has been approved for use in swine, Sequivity, contains RNA specific viruses, which is similar to mRNA vaccine technology, but still has some differing characteristics (Merck Animal Health, n.d.; Strickland, 2023). Additionally, Iowa State is currently conducting research on a novel mRNA vaccine that can be used for bovine respiratory viruses (Iowa State University, n.d.). mRNA vaccines have also been shown to help combat against porcine reproductive and respiratory syndrome (PRRS), which can cause an economic impact of 500 million dollars annually in the pork industry (Indiana Farm Bureau, 2023). The viability of other mRNA vaccines for animal diseases, such as foot and mouth disease, rabies, and avian influenza have been tested (Le et al., 2022). Research on mRNA vaccines for livestock have continued to emerge and show promising impacts for the livestock industry.

Current Trends in Public Perceptions

In recent years, heightened public scrutiny surrounding the use of mRNA vaccines in animal agriculture has contributed to a notable increase in the spread of misinformation related to the vaccine technology across social media platforms. In April of 2023, a post regarding mRNA vaccines in livestock went viral on multiple social media platforms. The post read:

> BREAKING NEWS: the lobbyists for the cattleman and pork associations in several states have CONFIRMED they WILL be using mRNA vaccines in pigs and cows THIS MONTH. WE MUST SUPPORT #Missouri #HB1169. It is LITERALLY the ONLY chance we have to prevent this...NO ONE knows the impacts of doing this but we are potentially facing the risk of being a #DiedSuddenly if we don't stop this. (Renz, 2023).

This post was viewed by thousands on various social media platforms (Frank, 2023). In March 2024, another video went viral on Instagram of a "5th generation cattle rancher" who reported statistics from an unverified research study conducted on mRNA vaccines in swine (Lazy J Meats, 2024). The "5th generation cattle rancher" goes on to say that remnants of the mRNA vaccine were later found in the meat (Lazy J Meats, 2024). A simple search for "mRNA vaccines in livestock" on any social media platform reveals widespread misinformation, making it increasingly difficult for both consumers and producers to differentiate accurate information from misinformation regarding the use of mRNA vaccines within the livestock industry.

With the rapid spread of misinformation about mRNA vaccines in livestock on media outlets, agriculturalists across the nation began releasing statements clarifying the inaccurate information. On April 5, 2023, the National Cattlemen's Beef Association (NCBA) released a statement saying, "There are no current mRNA vaccines licensed for use in beef cattle in the United States. Cattle farmers and ranchers do vaccinate cattle to treat and prevent many diseases,

but presently none of these vaccines include mRNA technology." (NCBA, 2023, para 1). The National Association of State Departments of Agriculture (NASDA) released a similar statement in February of 2024, adding that the association prioritizes animal and human health, but that researched and approved vaccines are a way for farmers and ranchers to mitigate risks (NASDA, 2024). Other organizations, such as the Oklahoma Cattlemen's Association, have indicated they have received questions from politicians and consumers regarding the mRNA vaccine (Oklahoma Farm Report, 2023). The rise in public concern regarding mRNA vaccine use supports prior research findings that consumers tend to show more concern when they cannot control outside actions, such as vaccinations (Scudamore, 2007).

Proposed Policy

With new public attention focused on mRNA vaccines, policies related to mRNA vaccines in livestock have been proposed throughout the United States in 2023 and 2024. The states that have recommended implementing such policy extend across the nation, including Idaho, Missouri, Arizona, North Dakota, South Carolina, Texas, and Tennessee (National Institute for Animal Agriculture [NIAA], 2023; Texas S.B. 119, 2023). In Missouri, Arizona, Texas, and Tennessee, legislation has been proposed that requires any food product derived from an animal administered the mRNA vaccine to have a label and/or disclosure indicating that animal received such vaccine (NIAA, 2023; Tennessee Farm Bureau [TNFB], 2023; Texas S.B. 119, 2023). In Arizona's and Tennessee's proposed bills, lawmakers included that veterinarians could not require the mRNA vaccine unless it was approved by the USDA and FDA (NIAA, 2023; TNFB, 2023). While not livestock focused, North Dakota proposed legislation that would ban all mRNA technology (NIAA, 2023). One of the most extreme policies proposed was by Idaho and South Carolina, where each state introduced a bill that would charge people of a

misdemeanor if they administered any form of mRNA vaccines to food-producing animals (Iowa State Research, 2023; NIAA, 2023). The proposed policies in each of these states have either failed to pass or have not received further discussion.

The proposal of these new policies has prompted action from state agriculture departments, state Farm Bureaus, and state and national livestock councils (National Pork Producers Council [NPPC], 2024; Nebraska Farm Bureau, 2023; Texas Department of Agriculture, 2023; TNFB, 2023). In Texas, Commissioner Sid Miller published a statement acknowledging the public concern of mRNA vaccines in livestock and his decision to create a task force to investigate the research and implications of the mRNA vaccine (Texas Department of Agriculture, 2023). Nebraska Farm Bureau introduced policy demonstrating they supported the approval and regulation of laws that protect the livestock industry from disease outbreak (Nebraska Farm Bureau, 2023). Tennessee Farm Bureau and the National Pork Producers Council (NPCC) rallied together to show their opposition to the proposed policies in Tennessee, confirming the safety of mRNA vaccines and suggesting that consumer confusion would be a result of the proposed policy (NPPC, 2024; TNFB, 2023).

The introduction of such policies across the nation suggests that the development and adoption of new vaccines may be limited due to public acceptance (Scudamore, 2007). This public pushback is a clear concern in the cattle industry given the corresponding statements made by national and state commodity organizations (NCBA, 2023; Oklahoma Farm Report, 2023) and the overall economic value of U.S. beef producers (USDA NASS, 2024b).

Purpose and Objectives

In response to public concern regarding the use of mRNA vaccine technology in livestock, the purpose of this research was to explore consumers' and producers' perceptions and

behaviors regarding the use of mRNA vaccines in beef cattle. Two research studies were conducted to fulfill this purpose.

Study #1: A Qualitative Exploration of Tennessee Direct-to-Consumer Beef Producers' Perspectives of mRNA Vaccines

The purpose of the qualitative study was to explore direct-to-consumer beef producers' awareness of the mRNA vaccine and the factors that would influence their decision to implement the vaccine technology (if FDA approved) on their operations in East Tennessee. The following research questions guided this study:

1. What are East Tennessee direct-to-consumer beef producers' current practices related to vaccine and antibiotic use in their cattle production?
2. What are East Tennessee direct-to-consumer beef producers' perceptions toward mRNA vaccines?

Study #2: A Quantitative Analysis of United States Consumers' Perspectives of mRNA Vaccines in Beef Cattle

The purpose of this quantitative survey study was to identify and understand the types of publics in the United States regarding the use of the mRNA vaccine technology in beef cattle. The aim of this study was to provide insight on how stakeholders within the beef industry of how they can effectively communicate with consumers about the mRNA vaccine. The following objectives guided this study:

1. Determine U.S. consumers' issue involvement, knowledge, attitudes, risk perceptions, and purchasing intent associated with the use of the mRNA vaccine in beef cattle.
2. Define the types of publics in relation to the use of the mRNA vaccine in beef cattle based on issue involvement and knowledge.

3. Compare U.S. consumers' attitudes, risk perceptions, and purchasing intent related to the use of the mRNA vaccine in beef cattle across identified groups of publics.

Significance

Technology in the agriculture industry is ever-evolving; however, the industry has witnessed how public opinions can limit the success of emerging technologies, such as genetically modified (GM) food products (Arujana, 2024). Therefore, the adoption and success of new technologies, such as mRNA vaccines, depends on public approval (Arujana, 2024; Huber-Eicher & Spring, 2008). The goal of this research is to provide evidence-based recommendations for proactive communication regarding mRNA vaccines in beef cattle, and to avoid missteps of the past with GM food products that relied on reactive communication (Arujana, 2024).

The increased nutrient demands of the growing population makes it important to create safe and affordable animal proteins (Henchion et al., 2017). At the time of this research, mRNA vaccines had not been approved for use in livestock in the United States (Strickland, 2023). However, research of mRNA vaccines has shown these vaccines to be a safe, efficacious, and cost-effective method (Gote et al., 2023; Rosa et al., 2021) that could protect food-producing animals from infectious diseases that are detrimental to the U.S. agriculture industry (Indiana Farm Bureau, 2023; Roth & Sandbulte, 2021). Therefore, understanding beef producers' perceptions and their future intent to adopt mRNA vaccines is essential for this vaccine technology to be a successful preventative technology.

Additionally, we have witnessed consumers sharing misinformation regarding the use of mRNA vaccines in livestock on social media (Frank, 2023) and proposing policies related to the regulation of the vaccine (Iowa State Research, 2023). The public must remain updated on

technologies based on science and not widespread information that may not be factual (Arujana, 2024). Considering mRNA vaccine technology has not been approved for use in the livestock industry, agricultural communicators must determine what is influencing U.S. beef consumers' concerns regarding the vaccine. Understanding consumer knowledge, concerns, and trust in the beef industry is important; therefore, the results of this research will provide agriculture communicators with a better understanding of the public's support and acceptance of mRNA vaccine use in beef cattle. The findings from this research can guide effective strategic communication, allowing consumers to form attitudes and make decisions based on factual information.

The success of the mRNA vaccine in the livestock industry is largely dependent on the perceptions of both producers and consumers. A strong, unified coalition of biotechnology advocates is essential to support focused outreach efforts (Arujana, 2024). Given the limited research on perceptions of mRNA vaccines in livestock, findings from this study will offer the agricultural sector a foundational understanding of how this novel vaccine technology is viewed by key stakeholders. These insights will enable Agriculture and Natural Resource Extension specialists and agricultural communicators to develop and disseminate accurate educational materials specific to mRNA vaccines in beef cattle. Additionally, pharmaceutical companies and governmental agencies will gain valuable information to guide decision-making prior to any potential future distribution. Industry associations and lobbyists will be better equipped when engaging in policy discussions, while meat processors and retailers will be more prepared to respond to consumer concerns if the vaccine is approved. Finally, research and academic institutions will be positioned to conduct further studies that expand upon the preliminary findings of this research.

Summary

Livestock vaccines are an important disease management tool for livestock producers (Armstrong, 2023; Roth, 2011). Vaccination decisions are made by the producer with guidance from a veterinarian (Pavlik et al., 2014), and producers must consider multiple factors when making vaccination decisions, such as economic implications and presence of disease (Ekakoro et al., 2019; Elbers et al., 2010); however, consumer perceptions also influence producers' vaccination decisions (Huber-Eicher & Spring, 2008). While consumers have an overall positive perception of the beef industry, safety is among a top concern when purchasing beef products (Beef Research, 2022a). Researchers have found consumers are fearful of new or unfamiliar vaccines (Ditlevsen et al., 2021; Scudamore, 2007), and this uncertainty can be seen in media (Scudamore, 2007), with one particular example being mRNA vaccine use in beef cattle (Frank, 2023).

mRNA vaccines were first introduced to the public during the COVID-19 pandemic (Le et al., 2022). They have the potential to not only protect human health, but also animal health. Research has been conducted on mRNA vaccines in livestock for over a decade, but they have not been approved for use in livestock in the United States (Strickland, 2023). Despite this, they have become a popular topic of conversation among the public (Frank, 2023; Iowa State Research, 2023; NCBA, 2023). Concerns surrounding the mRNA vaccine could limit the development of this new vaccine technology (Scudamore, 2007). Therefore, the overall purpose of this thesis was to examine consumers' and producers' perceptions and behaviors concerning the use of mRNA vaccines in beef cattle in response to public concerns about the technology. A qualitative and a quantitative study were conducted to gain a holistic perspective of the research problem (Moustakas, 1994). Using qualitative methods, one-on-one interviews were conducted

with East Tennessee beef producers to examine their perceptions of mRNA vaccines and their intent to implement the technology in their operations if approved in the future. Through a quantitative approach, a national survey was used to evaluate U.S. consumers' support of mRNA vaccines in beef cattle. Evaluating these perceptions at an early stage of the approval process will provide useful data to inform stakeholders in the beef industry, including meat processors, retailers, veterinarians, governmental agencies, research and academic institutions, pharmaceutical companies, and trade and industry associations.

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CHAPTER 2

A QUALITATIVE EXPLORATION OF TENNESSEE DIRECT-TO-CONSUMER BEEF PRODUCERS' PERSPECTIVES OF MRNA VACCINES

This article was authored by Bailey Watson. Taylor Ruth, Blake Colclasure, Katie Mason, and Shelli Rampold serve as co-authors. This research was presented at the Tennessee Steak and Potatoes Field Day as a research poster entitled "mRNA Vaccines in Cattle: Perspectives from Direct-to-Consumer Beef Producers in Tennessee". It was also presented at the National Agricultural Communications Symposium (NACS) as a research poster entitled "Cattle Conversations: Exploring Beef Producers' Perspectives of mRNA Vaccines". This article has been formatted for submission to Advancements in Agricultural Development.

Abstract

In recent years, the use of mRNA vaccines has gained increased public recognition. At the time of this study, mRNA vaccines had not been approved for use in livestock, yet research has shown promising implications of the vaccine in the animal agriculture industry. The purpose of this study was to understand direct-to-consumer beef producers' awareness of the mRNA vaccine and the factors that would influence their decision to implement the vaccine in their operations. This study was guided by the Theory of Planned Behavior, with knowledge being an additional measurement. Seven, semi-structured interviews were conducted with direct-to-consumer beef producers in East Tennessee in fall of 2023. The interviews were coded and analyzed by two researchers. The participants' vaccination protocols were evaluated to determine their current position on livestock vaccines. Some participants had current vaccination protocols they followed on their operations while others did not. Almost all of the participants administered antibiotics if needed. Participants exhibited low behavioral intent to implement the mRNA vaccine, which was likely influenced by weak attitudes, negative subjective norms, absent perceived behavioral control, and low knowledge. Extension specialists and agricultural

communicators should focus on educating producers on mRNA vaccines. Future research should examine consumer perceptions of mRNA vaccines in the livestock industry.

Introduction

mRNA vaccines were first introduced to the public during the COVID-19 pandemic, but their potential use in animal production did not gain public recognition until recent years (Le et al., 2022; Strickland, 2023). As of 2024, mRNA vaccines have not been approved for use in livestock in the United States; however, research studies are being conducted on the potential effects of the vaccine technology (University of Pennsylvania School of Veterinary Medicine, n.d.). mRNA vaccines have the potential to support agricultural development by enhancing resiliency in animal agriculture. These vaccines have the potential to combat infectious diseases that are detrimental to the livestock industry through efficacious and cost-efficient methods (Gote et al., 2023; Indiana Farm Bureau, 2023; Rosa et al., 2023).

Public opposition and concern regarding the use of mRNA vaccines in livestock have emerged on social media platforms (Frank, 2023), accompanied by the rise of anti-mRNA political initiatives (Iowa State Research, 2023), likely influenced by skepticism surrounding the COVID-19 vaccine (Graham, 2024). In response to growing misinformation, several agricultural and livestock organizations have issued press releases to clarify the regulation and application of mRNA vaccines in animal agriculture (National Association of State Departments of Agriculture [NASDA], 2024; National Cattlemen's Beef Association [NCBA], 2023). Negative consumer perceptions may hinder the adoption of these vaccines, posing risks to animal health and welfare. Such consequences could, in turn, affect the profitability and long-term sustainability of the livestock industry. Direct-to-consumer beef producers may feel these impacts more directly due to their ongoing, close interactions with consumers (Troy & Kerry, 2010; Whitt, 2022). To

safeguard animal and human health, as well as food security (Roth & Sandbulte, 2021), it is essential to understand how livestock producers perceive and intend to use emerging preventative tools like mRNA vaccines. Therefore, the purpose of this research was to explore direct-to-consumer, East Tennessee beef producers' perceptions of mRNA vaccines.

Theoretical Framework

The Theory of Planned Behavior (TPB; Ajzen, 1991) served as the theoretical framework to guide this study. The evaluation of attitudes, subjective norms, and perceived behavioral control can serve as strong predictors of behavioral intent, which is a direct predictor of behavior (Ajzen, 1991). Attitude is defined as the favorable or unfavorable view a person holds toward a certain behavior (Ajzen, 1991). Subjective norms determine how social pressure can impact a person's decision to implement a behavior (Ajzen, 1991). Lastly, perceived behavioral control describes an individual's perceived ability to implement a behavior, and is often associated with past experiences and potential consequences (Ajzen, 1991). While some variables may be more influential on behavioral intent than others, attitudes, subjective norms, and perceived behavioral control are all predictors of intent to engage in a behavior in the future (Ajzen, 1991).

Vaccine decisions are usually made by producers with guidance from their veterinarians, with vaccine protocol recommendations varying from one livestock operation to the next (Rodning et al., 2018). However, researchers have used TPB to examine livestock producers' intent to implement different disease management practices in their operations and determined that TPB and additional factors were influencing behaviors (Alarcon et al., 2014; Delgado et al., 2012; Faisal et al., 2020; Garforth et al., 2013; Stauder, 2023).

Garforth et al. (2013) found that knowledge, attitudes, subjective norms, and perceived behavioral control all impacted livestock producers' decision to implement certain disease

prevention practices on their operations. Delgado et al. (2012) used TPB to study behaviors in cattle producers' willingness to participate in foot-and-mouth disease (FMD) prevention programs. The researchers reported producers' attitudes, beliefs, trust, and subjective norms influenced their cooperation during a foot-and-mouth disease (FMD) outbreak (Delgado et al., 2012). Ellis-Iversen et al. (2010) conducted a study in the United Kingdom that used a socio-ecological model to identify factors that influence cattle producers' implementation of disease control programs. The researchers reported that unsupportive social norms from the community were influential to U.K. cattle producers' implementation of disease control programs (Ellis-Iversen et al., 2010). Lastly, Alarcon et al. (2014) used TPB to determine how information sources, attitudes, and behavioral controls impacted pig farmers' decision-making process for disease control. The researchers described that producers' lack of awareness of scientific research can impact their decision to implement disease-control measures and suggested ways to better communicate scientific information to producers (Alarcon et al., 2014).

While Ajzen (1991) had not included knowledge as an influence on behavioral intent in the original TPB model, researchers have found knowledge to be an influential determinant in livestock producers' decision-making process (Alarcon et al., 2014; Bhujel & Joshi, 2023; Delgado, 2012; Garforth et al., 2013; Kramer et al., 2017). Therefore, this study included knowledge as an additional measurement for behavioral intent. Within the context of this research, we used TPB to assess how attitudes, subjective norms, perceived behavioral control, and knowledge influenced direct-to-consumer beef producers' future intent to implement mRNA vaccines in their operations in East Tennessee.

Purpose

The purpose of this study was to explore direct-to-consumer beef producers' awareness of the mRNA vaccine and the factors that would influence their decision to implement the vaccine technology (if FDA approved) in their operations in East Tennessee. The following research questions guided this study:

1. What are East Tennessee direct-to-consumer beef producers' current practices related to vaccine and antibiotic use in their cattle production?
2. What are East Tennessee direct-to-consumer beef producers' perceptions toward mRNA vaccines?

Methods

To accomplish our research purpose, we conducted a basic interpretive qualitative study (Ary et al., 2010; IRB #F22 EX03 DC IRB HS; Appendix A). Basic interpretive qualitative studies aim to understand a phenomenon, process, or perspective by collecting descriptive accounts from those involved and analyzing the collected data to identify recurrent patterns or themes (Ary et al., 2010). In-depth, one-on-one interviews were conducted with direct-to-consumer East Tennessee beef producers. To create our population parameters, we recruited participants using the *Spring 2023 - Spring 2024 East Tennessee Local Food Guide* (Nourish Knoxville, 2023). There were a total of 35 (N = 35) beef producers identified through the publication that met our parameters of raising and marketing their beef to local consumers. Every producer in our sampling frame was contacted via phone or email and invited to participate in the study. The purpose of the research was described to the potential participant, and they were offered a $100 incentive to participate in a one-on-one interview. Seven beef producers (n = 7; 20% participation rate) participated in our research study. While the sample size is relatively

small, this is typical in qualitative research, as there is no required minimum number of participants (Ary et al., 2010). Instead, qualitative researchers use purposive sampling to gain meaningful insight into a topic (Ary et al., 2010). Due to the depth of information collected, purposive samples are often small (Ary et al., 2010). Sampling is typically concluded once data saturation is reached meaning when no new information emerges from additional interviews (Ary et al., 2010).

A semi-structured interview guide consisting of five sections and approximately 40 questions/discussion points (Appendix B) was constructed to facilitate the one-on-one, in-depth interviews. The semi-structured interview guide provided us with the flexibility to ask follow-up questions that would provide thick and rich data (Morse, 2015). In the fall of 2023, interviews were conducted via phone out of convenience for the beef producers. This modality has been supported in prior research (Cachia & Millward, 2011). The average interview was 55 minutes in duration. Each interview was recorded via Zoom and the audio was transcribed using a 3rd party.

For analysis, the interview transcripts were uploaded to NVivo, a computer software used for qualitative coding. A codebook that defined TPB's predictors of behavioral intent (Ajzen, 1991) was established prior to the data analysis process using deductive methods (Bingham & Witkowsky, 2022). Emerging codes were added throughout the coding process, with the final codebook consisting of 18 codes, each having a definition and example. Each code and its corresponding information were exported into separate documents where the researchers worked together to generate themes to answer the research questions. The findings were confirmed by reviewing researcher notes, comparing the findings to the TPB (Ajzen, 1991), and revisiting our audit trail (Carter et al., 2014).

Creswell (2013) encourages qualitative researchers to engage in two or more validation strategies in a study. The validation strategies used in this study included member checking, clarifying researcher bias, and peer debriefing (Creswell, 2013). Creswell (2013) indicated that member checking is done by having participants confirm the credibility of the findings and interpretations. Member checking was conducted at the conclusion of each interview to allow the participants to confirm the data was accurately presented and interpreted. Creswell (2013) described peer debriefing as an external check of the research process. The two researchers utilized peer debriefing (Creswell, 2013) by coding the interviews separately then reconvening to confirm and/or discuss codes until coding agreement was formed. A third researcher reviewed the final analysis to provide alternative perspectives and challenge perspectives as part of the peer review process. Clarifying researcher bias is done by acknowledging past experiences, biases, prejudices, and orientations that could shape the interpretation of the study (Creswell, 2013). The two researchers clarified researcher bias by acknowledging during the coding process that subjectivity that could emerge throughout the analysis. One coder had an extensive background in both qualitative research and sustainable agriculture. The other coder had limited experience with qualitative research but had an extensive background in beef production.

Findings

To provide greater context for the findings of this study, a description of the participants is detailed in **Table 2.1**. To help protect the anonymity of the participants, we have used pseudonyms in place of their real names. Due to the small population size, we have also chosen to report participant demographics in aggregate to help further protect anonymity. The participants were split between males (n = 4) and females (n = 3), and four (n = 4) out of the 7 participants were 51 years old or older. We also asked about herd size, and the most common

Table 2.1. ***Participants' Characteristics and Production Practices***

	# of Participants
Gender	
Male	4
Female	3
Age	
30 years old or less	2
31 years old to 50 years old	1
51 years old or greater	4
Size of Operation	
50 head of cattle or less	1
51-100 head of cattle	1
101-200 head of cattle	3
201-500 head of cattle	1
501 head of cattle or greater	1
Marketing Approach[a]	
Farmer's market	3
Website	4
Custom and retail beef	3
Other	2

Table 2.1. ***Participants' Characteristics and Production Practices cont.***

	# of Participants
Administers Vaccines?	
Yes	4
No	3
Administers Antibiotics?	
Yes	6
No	1

[a]Most participants used multiple marketing approaches.

herd size was 101-200 head of cattle (n = 3). The most common marketing approach used by participants was websites (n = 4). Four (n = 4) of the participants had implemented vaccine programs at their operations while the other three (n =3) did not have existing vaccine programs. Additionally, nearly all (n = 6) of the participants reported they did or would administer antibiotics to their cattle.Research Question 1: What are East Tennessee Direct-to-Consumer Beef Producers' Current Practices Related to Vaccine and Antibiotic Use in Their Cattle Production?

In the analysis of Research Question 1, two themes emerged: (1) *diversified vaccine perceptions and behaviors,* with subthemes of *production benefits* and *consumer interactions*; and (2) *utilization of antibiotics.*

Diversified Vaccine Perceptions and Behaviors

The findings from this theme were affiliated with participants' perceptions and behaviors about livestock vaccines not related to mRNA vaccines. The participants' opinions about livestock vaccines and vaccination programs were variable, as indicated by the producers expressing negative, neutral, and positive perceptions toward livestock vaccines. The sub-themes of *production benefits* and *customer interactions* were identified during the analysis.

Production Benefits. Participants who administered vaccines to their beef cattle implied they did so as a preventative measure for *production benefits*, including their operation's economic interest and to protect animal health. Sarah stated, "We always want to make sure to vaccinate for precautions of Blackleg [and] pink eye...Blackleg will kill them...if you get one that gets Blackleg, then you might have a [larger] issue in [the herd]." Sam saw economic benefits in administering vaccines by stating, "the consequences...would be much more expensive than [the] vaccine. So, it makes sense to do it." While Sam was concerned about the economic

sustainability of his operation, he also took “responsibility [in making sure] the animal is healthy.” He demonstrated his concern for his animals’ welfare by stating, “...if something goes south, the animal is the one that suffers.”

Conversely, the participants who did not administer vaccines believed there would not be production benefits associated with vaccine use. These producers were content with their herd’s health or held beliefs in different disease-control programs. Sally “[does] not vaccinate on a regular basis” but stated that, “we don’t have a lot of trouble with disease or sickness.” She accredited this to “deworm[ing]” and “hav[ing] a closed herd.” David demonstrated his satisfaction with his herd’s health by stating, “At this point, I’ve not had the issue or needed to vaccinate.”

Customer Interactions. *Customer interactions* was the second sub-theme that emerged related to vaccine protocols. Participants described how discussions with their customer base had some influence on their vaccination decisions. The participants who administered vaccines and sold beef directly to the consumer had customers who supported the use of their vaccine programs. Sam mentioned that he “had to educate some [of his customers] on [his] health protocols.” Sam went on to further explain that “once they understand what we do, why we do it...it’s perfectly fine. There’s no stigma to it.” Harry used vaccines on his operation, but he only occasionally marketed beef direct-to-consumer. He mostly markets bulls, steers, and heifers, but does sell “some freezer beef” by “word of mouth.” He informed us that “most of the people that buy [his freezer beef] have been here at the farm and see [the cattle].” Due to Harry’s marketing practices mostly focusing on the live animal at “sales” and “to neighbors” rather than an edible product, he rarely had interactions with the individuals consuming his products.

Other participants' customer base did not express favorable perceptions regarding vaccines. Consumer opinions appeared to influence some of the beef producers' decision not to administer any vaccines to their cattle. The consumer-driven decision to refrain from implementing vaccine protocols was demonstrated by David, who stated, "Well, we don't do any vaccines. And that's just kind of what our clientele has wanted, so that's what we've had to move to." When asked what customers were asking for, Dale mentioned, "[I have] customers that don't want any growth hormones added or they like the antibiotic-free animals." Both David and Dale have encountered consumer pushback regarding vaccine use that influenced their decision to not implement vaccines.

Utilization of Antibiotics

The findings from this theme were related to the use of antibiotics in the participants' operation. The participants held consistent views toward antibiotic use in beef cattle. All but one of the participants (Dale) mentioned the use of animal antibiotics on their operations and agreed to only using antibiotics when the animal was sick, out of benefit for the animal. Sally shared, "We treat [our cattle] if needed, but we don't treat just to treat." Sam illustrated his awareness of the precautions that should be taken to protect human health when administering antibiotics by stating, "If we do use antibiotics, obviously we go through the withholding period. We're not treating any of the steers that are ready to be harvested. So, there's really no risk there."

Other participants expressed only using antibiotics in certain cases. For example, Dale did not use antibiotics on the beef he is selling direct-to-consumer because he markets them as "Antibiotic Free." Tammy mentioned that she does not have to use antibiotics because she believed the breed of cattle she raised were "generally disease free" and that they tend to overcome illnesses with "very little to no human interaction." However, she continued on to say,

"The only time we even administer antibiotics is if it's an animal that is on death's door. And that is not something that we would eat…We wouldn't sell that."

Research Question 2: What are East Tennessee Direct-to-Consumer Beef Producers' Perceptions Toward mRNA Vaccines?

The participants' perceptions toward mRNA vaccines were examined using the TPB (Ajzen, 1991) with the addition of knowledge. Using this criterion, we defined the following three themes: *low producer knowledge, weak attitudes, and significant consumer mRNA vaccine concerns (subjective norms).* However, *perceived behavioral control,* a key variable in the TPB model (Ajzen, 1991*),* did not emerge as a theme during analysis.

Low Producer Knowledge

Overall, participants demonstrated some awareness, but a general lack of knowledge, regarding mRNA vaccines for livestock. Most participants indicated they were aware of the mRNA vaccine. When asked if he had heard about the mRNA vaccine, Harry simply stated "no," making him the only participant to lack any awareness of the vaccine. Sam stated, "I don't know much about it. As far from what I know we don't have it on the market yet." Sally had heard of the mRNA vaccine, but implied that she "[didn't] know enough about it." Sarah stated, "I've heard of the mRNA vaccine, but we don't use [it]." Sarah's lack of knowledge concerning the mRNA vaccine was further demonstrated by her saying, "I haven't done enough research on it (the mRNA vaccine) yet, but I need to. I need to ask the extension [agent] or talk to somebody like the veterinarian on the mRNA [vaccine]".

Weak Attitudes

The participants reported weak attitudes toward the use of mRNA vaccines in livestock. In this context, "weak" describes a range of responses that were diverse but leaned toward being

unsupportive or neutral. Sam demonstrated that he did not see any additional benefits to using the mRNA vaccine by stating, “Our vaccination program is working. And so, if it’s not broken, I don’t see any reason to change it.” Opposing opinions related to the mRNA vaccine also emerged in our analysis. After explaining the mRNA vaccine technology, Harry indicated that the use of mRNA vaccines in livestock, “might be a pretty good thing.” On the other hand, Tammy held strong opinions against the use of mRNA vaccines in livestock. When asked if she would use the mRNA vaccine in her operation she stated, “Absolutely not.” She went on by explaining, “If you’re going to mandate something that we don’t have enough information or long-term study on, forget about it.” We found that other participants’ attitudes toward mRNA vaccine administration in livestock were linked to low knowledge as well. Dale said, “I’m still undecided on [the use of mRNA vaccines] personally. I’m kind of neutral at this point because I don’t think I have enough information on it to make a decision whether I think it’s good or bad.” Sam mentioned, “it would really take a really bad situation to even consider it.”

Significant Consumer mRNA Vaccine Concerns (Subjective Norms)

Subjective norms emerged during the analysis as participants discussed how customers have expressed concerns about the use of the mRNA vaccine in beef cattle. For participants who had experiences with customers asking about the mRNA vaccine, all described strong consumer concerns. Tammy shared she had received, “many calls and texts…from [customers] saying, ‘Please tell us that you’re not doing this (using mRNA vaccines).’” When asked about the interactions he had with customers about the mRNA vaccine, David said his interactions were, “mostly negative, mostly a lot of uncertainty around them [from consumers].” David continued to say, “I guess you hear positive things from your cattlemen’s association or your beef magazine or...these huge pharmaceuticals [that] are pushing them into the industry...but on a ground level,

no. I've not heard anything positive about it." Sam shared, "I've had folks ask me about [the mRNA vaccines] at farmers markets and online and I said no we don't use them." He stated that his consumers were "not wanting" to purchase beef that had been administered with mRNA vaccines. Overall, participants expressed that their consumers were concerned about the use of the mRNA vaccine in beef cattle.

Conclusions, Discussions, & Recommendations

Overall, participants exhibited low behavioral intent to implement mRNA vaccines in their cattle operations if they were to be approved in the future. A general lack of knowledge regarding mRNA vaccines and consumer preferences for mRNA vaccine-free beef appeared to be strongly linked to participants' low intent to use mRNA vaccines in the future, which aligns with past research (Alarcon et al., 2014; Delgado et al., 2012; Ellis-Iverson et al., 2010; Garforth et al., 2013). Most participants indicated they were aware of mRNA vaccines in livestock but lacked further knowledge on these vaccines. One participant explicitly mentioned they did not currently use mRNA vaccines on their operation, making us believe that some producers may not be aware of the regulatory status of mRNA vaccines. Attitudes toward mRNA vaccines varied between participants, but the participants' lack of knowledge likely explained this variability. Some participants explained they did not feel like they could form an attitude toward the mRNA vaccine due to their limited knowledge, indicating attitudes were likely weak. However, participants' farm characteristics may also explain their attitudes and intent to use mRNA vaccines in the future. For example, participants who had smaller herd sizes reported not using any vaccines on their operations, likely because a potential disease outbreak could be easier to control. So, it is not surprising these participants would not hold favorable attitudes toward mRNA vaccines or see a need to implement them in their operations.

Participants reported that their consumers had concerns related to mRNA vaccines being used in their operations, which reflected how the vaccine has been discussed in the media (Frank, 2023). Many participants indicated they would lose business due to their consumers' concerns if they were to use mRNA vaccines in their operation, demonstrating the influence of subjective norms on behavioral intent (Ajzen, 1991). However, behavioral control did not emerge in our analysis of the discussions likely due to these vaccines not being available for use in beef cattle. Even if approved in the future, perceived subjective norms related to mRNA vaccines would likely remain a strong influence on behavioral intent because of participants' direct-to-consumer marketing approach.

Based on TPB, participants' weak attitudes, perceived negative subjective norms, and the absence of perceived behavioral control would likely lead to low behavioral intent to implement mRNA vaccines on their cattle operations (Ajzen, 1991). Additionally, knowledge appeared to indirectly impact behavioral intent but was likely a determinant of attitudes.

Due to the qualitative nature of this study, our findings are not generalizable to the overall population. However, our findings do provide insight into the potential behavior of direct-to-consumer cattle producers if mRNA vaccines become authorized for use in the future. Our participants mostly demonstrated that they did not see any additional benefits in mRNA vaccines, despite research showing otherwise (Gote et al., 2023; Indiana Farm Bureau, 2023; Rosa et al., 2021). Extension specialists and agricultural communicators should create outreach campaigns and programs that educate beef producers, particularly direct-to-consumer beef producers, on the mRNA vaccine technology and the regulations that surround it. This would provide beef producers with more knowledge on the mRNA vaccine so they can be better equipped to have conversations with their consumers. Transparent communication to producers

related to the benefits of implementing mRNA vaccines on their operations and how to overcome consumer stigma will be crucial to the success and implementation of this vaccine if approved. Additionally, practitioners should focus on strategic, transparent communication with consumers about the mRNA vaccine to overcome misinformation and negative perceptions, thus promoting the security and vitality of the livestock industry.

This research could be replicated in other regions of Tennessee and in other states in the United States. In addition, it would be beneficial to evaluate different stakeholders' opinions of mRNA vaccines, such as large-scale commercial beef operations, meat processors, and cattlemen's groups. Studies focused on these stakeholder groups could use qualitative methods to gain additional rich insight; however, quantitative research is also recommended to better understand how the variables of TPB predict intent to use mRNA vaccines. Additionally, including other variables to TPB, like knowledge and producer characteristics, would help to strengthen the applicability of the model. Additionally, to better guide strategic communication on mRNA vaccine technology in livestock, we recommend future research to examine consumers' perceptions of mRNA vaccines and what influences their purchasing decisions. If the mRNA vaccine were to be approved for use in livestock, future researchers should examine producers' adoption of the vaccine through other frameworks, such as Rogers' (2003) Diffusion of Innovations Theory.

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CHAPTER 3

A QUANTITATIVE ANALYSIS OF UNITED STATES CONSUMERS' PERSPECTIVES OF MRNA VACCINES IN BEEF CATTLE

Abstract

While research has shown potential opportunities for messenger RNA (mRNA) vaccines to combat diseases that are detrimental to the animal agriculture industry, as of 2025, they have not been approved in the United States for use in livestock. Despite this lack of approval, consumers have voiced their concerns about mRNA vaccines and lawmakers have brought forth proposed policies undermining the potential use of mRNA vaccines in livestock. The purpose of this study was to identify and understand the types of publics in the United States regarding the use of the mRNA vaccine technology in beef cattle. This study used the Situational Theory of Publics (STOPs) and the Five Publics Model Based on Knowledge and Involvement to examine consumers' perceptions of mRNA vaccines in beef cattle. An online survey was completed by 519 U.S. beef consumers (n = 519). Attitudes, knowledge, issue involvement, risk perceptions, and purchasing intent were evaluated, and respondents were categorized as active, aware, aroused, or inactive publics, with inactive publics being the largest group in the sample. This study highlights the importance of strategic communication efforts in addressing potential misinformation and public concern. Agricultural communicators and industry stakeholders can use these findings to inform targeted messaging strategies that enhance consumer education and acceptance of mRNA vaccines in beef cattle.

Introduction

There are many different vaccine technologies used in the livestock industry to reduce the risk of diseases. Some of the most common vaccine technologies used include inactivated vaccines, live-attenuated vaccines, and toxoid vaccines (Campos & Bittar, 2024). However, after decades of research, scientists are beginning to advocate for the approval of a new vaccine technology that could be used to protect animal health: messenger ribonucleic acid (mRNA)

vaccines (Mahony et al., 2024; Verbeke et al., 2019). mRNA vaccines contain genetic material that teaches cells how to make a protein that will create an immune response against a specific disease (Strickland, 2023). While research related to mRNA has been conducted for decades, the majority of the public was first introduced to the technology with COVID-19 vaccines in 2021 (Pfizer, n.d.). During the COVID-19 pandemic, the U.S. Food and Drug Administration (FDA) approved the use of Pfizer's COVID-19 mRNA vaccine in humans, the first of its kind, and it has since been proven to be safe and efficacious against the virus (Beyrer, 2021). The success of the COVID-19 vaccine inspired researchers to evaluate the potential benefits of using mRNA vaccines outside of human medicine (Penn Medicine, n.d.).

At the time of this study, mRNA vaccines have not been approved for use in livestock in the United States (Strickland, 2023). However, ongoing research has continued to be conducted to identify opportunities for the mRNA vaccine to advance animal medicine (University of Pennsylvania School of Veterinary Medicine, n.d.). In May 2024, the U.S. Department of Agriculture (USDA) announced it would begin testing the use of avian flu mRNA vaccines in dairy calves in response to the bird flu outbreak (Stobbe & Neergaard, 2024). The objective of this vaccine development was to create immunity in calves to protect dairy workers and prevent the virus from mutating and spreading to other humans (Stobbe & Neergaard, 2024). Researchers have found that mRNA vaccines can create a more efficacious immune response and be produced at a lower cost compared to traditional vaccines (Gote et al., 2023; Rosa et al., 2021). Additionally, mRNA vaccines can be pragmatic to combat detrimental animal and zoonotic diseases such as foot and mouth diseases, rabies, and avian influenza (Le et al., 2022).

Consumer Perceptions of mRNA Vaccines

Despite the mRNA vaccine not being approved for use in livestock and the potential benefits of its use (Strickland, 2023; University of Pennsylvania School of Veterinary Medicine, n.d.), a growing segment of consumers have vocalized their concern and opposition toward the use of the vaccine in livestock. On social media platforms, consumers have criticized the use of mRNA vaccines in livestock (Frank, 2023). In April 2024, a post on X read:

> BREAKING NEWS: the lobbyists for the cattleman and pork associations in several states have CONFIRMED they WILL be using mRNA vaccines in pigs and cows THIS MONTH. WE MUST SUPPORT #Missouri #HB1169. It is LITERALLY the ONLY chance we have to prevent this...NO ONE knows the impacts of doing this but we are potentially facing the risk of being a #DiedSuddenly if we don't stop this. (Renz, 2023).

While this social media post was not true due to mRNA vaccines not being approved for use in livestock (Strickland, 2023), the post was shared more than 25,000 times (Frank, 2023). Another example can be seen in a video by a self-identified "5th generation cattle rancher" who reported on Instagram that an unverified research study found remnants of the mRNA vaccine were found in pork (Lazy J Meats, 2024). While this post was not sharing accurate or proven research, the Instagram video was liked by 57,000 users and shared over 6,000 times (Lazy J Meats, 2024). Social media has been known to cause a rapid diffusion of misinformation (Wu et al., 2019), which appears to be occurring across different social media platforms regarding the mRNA vaccine.

Consumers' apprehension of mRNA vaccines in livestock has brought forth proposed policies across the United States (Iowa State Research, 2023). For example, lawmakers have proposed policies that food products derived from animals that have received the mRNA vaccine

should require a disclosure statement on the packaging (Iowa State Research, 2023) and that veterinarians cannot mandate mRNA vaccines (Tennessee Farm Bureau, 2023). Seeing that mRNA vaccines are currently not approved for use in livestock (Strickland, 2023), these proposed policies were unnecessary at the time of proposal. Agriculture and livestock associations have attempted to clarify any miscommunication about the regulation and use of mRNA vaccines through press releases (National Association of State Departments of Agriculture [NASDA], 2024; National Cattlemen's Beef Association [NCBA], 2023), but this has not halted consumers' concerns related to the technology.

Consumers' perceptions and opinions of mRNA vaccines could limit the development and implications of this technology due to public opposition (Scudamore, 2007). Consumer opinions can also influence livestock production decisions, such as vaccine selection and use (Ellis-Iverson et al, 2010). In order for mRNA vaccines to be a successful disease-management tool for livestock producers (Le at al., 2022), public support is needed. Consumers' differing opinions toward mRNA vaccines in livestock are likely reinforced on social media through filter bubbles and echo chambers (Rhodes, 2022). These filter bubbles and echo chambers would reinforce opinions and create different groups of publics that are receiving different information. Therefore, the purpose of this research was to determine the demographic characteristics of different publics regarding the support of mRNA vaccines in beef cattle to inform effective strategic communication so consumers can form attitudes and make decisions grounded in factual information.

Theoretical Framework

The theoretical framework used in this study is the Situational Theory of Publics (STOPs; Grunig, 1983), and the Five Publics Model Based on Knowledge and Involvement (Hallahan,

2000). Dewey (1927) defined a public as a group of people who collaborate to face a similar issue. Since then, the definition has expanded to include that publics can be receivers of messages, people who share similar demographic or psychographic characteristics, people who are united by shared experiences, or those who are impacted by the organization (Hallahan, 2000). First proposed by Grunig (1983), STOPs presents that publics form based on how a problem impacts them and suggested using audience segmentation to separate different types of publics into sub-categories. Identifying different sub-groups of publics can allow communicators to better tailor their messages to the key audiences invested in a problem or issue rather than using a universal message that may not resonate across all audiences (Kotler et al., 2002).

Grunig (1983) identified four categories of publics: nonpublics, latent publics, aware publics, and active publics. These groups of publics were created based on the audience's issue involvement, problem recognition, and constraint recognition (Grunig, 1983). Issue involvement is defined as a person's personal connection to a problem, and problem recognition is operationalized by a person's acknowledgement that the problem impacts them. Finally, constraint recognition is determined by the extent to which a person believes they can do something about the problem. **Table 3.1** summarizes how Grunig (1983) defines each public category.

Hallahan (2000) expanded on Grunig's (1983) STOPs to create the Five Publics Model Based on Knowledge and Involvement, which served as the framework for this study (**Figure 3.1**). This model consists of five groups of publics: aware, active, aroused, inactive, and nonpublics. Hallahan's (2000) model splits Grunig's (1983) categorization of latent publics into aroused and inactive publics. In Hallahan's (2000) model, publics are categorized by their amount of knowledge (high/low) and their level of issue involvement (high/low).

Table 3.1. ***Grunig's (1983) Categories of Publics***

Public Category	Definition
Active	High issue involvement, high problem recognition, and low constraint recognition (Rawlins, 2006)
Aware	Low issue involvement, high problem recognition, and high constraint recognition (Rawlins, 2006)
Latent	Low issue involvement, low problem recognition, and low constraint recognition (Rawlins, 2006)
Nonpublic	Individuals who do not face a problem (Rawlins, 2006)

	Low Involvement	High Involvement
High Knowledge	Aware Publics	Active Publics
Low Knowledge	Inactive Publics	Aroused Publics

No Knowledge/No Involvement

Non-Publics

Figure 3.1. ***Hallahan's (2000) Five Publics Model Based on Knowledge and Involvement***

Knowledge refers to a person's beliefs and attitudes of an object, person, situation, or organization based on everyday experience or formal education (Hoch & Ha, 1986). Involvement refers to the amount of relevance a person holds toward an object, person, situation, or organization (Petty & Cacioppo, 1986).

Active publics are categorized by high knowledge and high involvement and are most likely to become involved in a problem directly (Hallahan, 2000). Hallahan (2000) encourages communication that acknowledges, provides support, engages, and negotiates with active publics. The alteration of organizational policies and third-party intervention may be needed with active publics (Hallahan, 2000). Aware publics are categorized by high knowledge and low involvement. While they are knowledgeable of a problem, they may not feel impacted by it directly (Hallahan, 2000). However, aware publics might attempt to influence others on the issue (Hallahan, 2000). Hallahan (2000) suggests that communicators monitor the behavior, supply information, and encourage or discourage influential roles of aware publics.

Aroused publics are categorized by low knowledge and high involvement. These publics have low levels of knowledge of a problem but feel that they are directly impacted by the problem (Hallahan, 2000). An aroused public may attempt to increase their knowledge of a problem to reduce uncertainty (Hallahan, 2000). Communicators should monitor behavior of aroused publics, understand why aroused publics take interest in a problem, and supply them with information that addresses their concerns (Hallahan, 2000). Inactive publics are categorized by low knowledge and low involvement and do not have the desire to become directly involved in the problem (Hallahan, 2000). Hallahan (2000) argues that communicators should not merely ignore inactive publics but should create opportunities to build relationships with them.

STOPs has been used as a framework in past research related to agricultural and natural resources, with Burke et al. (2020) using STOPs to identify characteristics of millennials and their perceptions toward genetically modified (GM) food. The researchers found that the majority of their respondents were not supportive of GM food, with most non-supportive respondents having high issue involvement and low knowledge. In addition, they reported that most respondents who supported GM foods had low issue involvement. Ruth et al. (2017) used STOPs to identify the types of publics related to the issue of citrus greening to determine effective communication strategies for the disease. The researchers found that the majority of their respondents had low issue involvement and high knowledge about citrus greening in citrus-producing states (Ruth et al., 2017). For the context of this research, we examined respondents' issue involvement and knowledge associated with the use of mRNA vaccines in beef cattle to create the categories of publics.

Purpose and Objectives

The purpose of the study was to identify and understand the types of publics in the United States regarding the use of the mRNA vaccine technology in beef cattle. The aim of this study was to provide insight on how stakeholders of the beef industry can effectively communicate with consumers about the mRNA vaccine. The following objectives guided this study:

1. Determine U.S. consumers' issue involvement, knowledge, attitudes, risk perceptions, and purchasing intent associated with the use of the mRNA vaccine in beef cattle.
2. Define the types of publics in relation to the use of the mRNA vaccine in beef cattle based on issue involvement and knowledge.
3. Compare U.S. consumers' attitudes, risk perceptions, and purchasing intent related to the use of the mRNA vaccine in beef cattle across identified groups of publics.

Methods

Quantitative methods, using an online survey, were used to fulfill the purpose of this research study (IRB# UTK IRB-24-08366-XM; Appendix C). The survey instrument (Appendix D) was distributed by Qualtrics in November of 2024. Non-probability, quota sampling was used to match the U.S. Census for age, gender, race, and ethnicity. Public opinion researchers often use non-probability sampling (Baker et al., 2013) as it has been proven to be as effective, if not more effective, than traditional probability samples (Twyman, 2008; Vavvreck & Rivers, 2008). Quota sampling reduces limitations and the amount of bias that is often associated with non-probability sampling in regards to generalizability (Baker et al., 2013). The population of interest for this study was U.S. residents over the age of 18 who had purchased and/or consumed beef products in the past six months before data collection. Screening questions were asked at the beginning of the survey about quota demographics and beef purchasing/consuming behaviors. If respondents' indicated they had not purchased/consumed beef in the last six months, they were dismissed from the survey and their response was discarded.

Description of Respondents

The survey was distributed to a panel of 901 respondents in the United States, and in total, there were 519 (n = 519) complete and usable responses. While the researchers had requested Qualtrics to implement quotas to match the U.S. census for demographics, some of the quotas were relaxed, likely due to the screening question related to purchasing or consuming beef in the last six months. A full description of respondents can be found in **Table 3.2.** Additionally, **Table 3.2** contains 2020 U.S. census data, where available, to allow for a comparison between the sample and the population. Over half (55.7%) of the respondents were 65 years or older, which does skew this sample as older compared to the U.S. population.

Table 3.2. ***Description of Respondents (n = 519)***

	%	U.S. Census Estimates (%)
Age		
18-24	1.3	9.9
25-44	14.7	26.6
45-64	28.3	26.4
65+	55.7	13.0
Gender		
Female	66.7	50.8
Male	32.8	49.2
Other	0.5	
Race/Ethnicity		
White	82.5	75.3
African American	12.3	13.7
Hispanic	4.4	19.5
Other	4.0	
Education		
High School or less	24.8	9.0
Some College	26.4	15.0
2-year College Degree	14.3	10.0
4-year College Degree	19.5	23.0
Graduate or Professional School	15.0	14.0

Table 3.2. ***Description of Respondents (n = 519) cont.***

	%	U.S. Census Estimates (%)
Income		
Less than $25,000	21.0	15.2
$25,000 - $49,999	30.1	17.1
$50,000 - $99,999	31.4	28.8
$100,000 - $149,999	10.9	17.4
$150,000 or more	6.6	21.5

Additionally, the majority of the respondents were female (66.7%), which is a larger than the 50.8% of females identified in the census. The sample was also majority white (82.5%) and approximately one-fourth (24.8%) of respondents' education level did not go beyond a high school degree, which is disproportionately larger than the population. The largest income group was $50,000-$99,999 (31.4%), and most of the respondents' income was generated from a non-farming household (96.5%). Differences between sample and population demographics should be considered when interpreting the findings from this study.

Table 3.3 provides a description of additional demographic information of respondents. More than one-third (40.7%) of the respondents identified their political affiliation to be moderate. More than half (51.4%) of the respondents indicated they lived in a suburban area. There was a minimal number of respondents who had children in the home (15.8%). Facebook was the most popular social media application used by respondents (76.1%).

Instrument

Five survey constructs were analyzed for this study including attitudes, knowledge, purchasing intent, issue involvement, and risk perceptions of mRNA vaccines in beef cattle (Appendix E). The survey instrument was reviewed by a panel of three experts with experience in agriculture communications and animal science to account for content and face validity (Ary et al., 2010). The instrument was piloted with students enrolled in a summer course at the University of Tennessee – Knoxville to ensure there were no issues with data collection and the instrument worked as expected. Appropriate edits were made before the survey was launched. Three cognitive interviews were conducted to verify the validity of the instrument and adjustments were made upon completion of the interviews. The survey was soft launched before it was distributed to confirm the instrument was working as expected.

Table 3.3. ***Description of Additional Demographics (n = 519)***

	%
Income Source	
Farming household	3.5
Non-farming household	96.5
Political Affiliation	
Very Liberal	9.8
Liberal	18.7
Moderate	40.7
Conservative	19.1
Very Conservative	11.7
Location	
Urban	24.7
Rural	23.9
Suburban	51.4
Children in Home	15.8

Table 3.3. ***Description of Additional Demographics (n = 519) cont.***

	%
Social Media Applications Used[a]	
Facebook	76.1
YouTube	60.9
Instagram	33.7
TikTok	23.1
Pinterest	22.5
Twitter	18.7
Reddit	12.7
Snapchat	11.9
None	9.4
Other	3.9

[a]Respondents were asked to select social media applications they used at least once a week in a check-all-that-apply format.

Attitude toward consuming or purchasing beef products from cattle administered a mRNA vaccine was measured using an 8-item, 5-point, bipolar semantic differential scale that was adapted from a previous study (Ruth et al., 2019). Respondents were asked to select a circle between a set of adjectives that best represented their thoughts following the stem, "Purchasing and consuming beef from cattle administered a mRNA vaccine is…". Adjectives included: *Good/Bad, Negative/Positive, Not Beneficial/Beneficial, Acceptable/Unacceptable, Necessary/Unnecessary, Unimportant/Important, Not essential/Essential, Crucial/Trivial.* Responses were coded so that positive adjectives were assigned a *5* and negative adjectives were assigned a *1*. The Cronbach's alpha for this scale was .94, and therefore above the 0.70 criteria for reliability (Field, 2013). The index was calculated by averaging the scale items

Twelve questions were asked to measure knowledge toward mRNA vaccines in cattle. These questions were researcher developed and were related to vaccine regulations, vaccination practices, and mRNA vaccines in beef cattle. Respondents could answer each question by selecting *True, False,* or *I don't know.* The "I don't know" option was included to lessen the chance of respondents guessing for their responses (Burton, 2004). The questions were reviewed for accuracy by a panel of experts, including three researchers in Agricultural Leadership, Education, and Communications and one researcher in Animal Science at the University of Tennessee – Knoxville. To create the index for knowledge, each question was transformed into a dichotomous question where a *1* = correct response and *0* = incorrect/don't know responses. Knowledge was treated as a count variable, and correct responses added together so the index could range from zero to twelve. The Kuder-Richardson formula (Kuder & Richardson, 1937), often referred to as KR20, was used to calculate reliability. KR20 is a form of Cronbach's alpha

that is used to measure the reliability of dichotomous variables (Huck, 2008), including true-false tests (Burton, 2004). The KR20 test indicated that Cronbach's alpha for knowledge was .62.

Purchasing intent was measured by a 4-item, 5-point Likert-type scale that consisted of the following items: *1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree.* Purchasing intent was presented after the attitude and knowledge questions, and respondents were provided with a definition of mRNA vaccines prior to answering questions The definition read: "A messenger Ribonucleic acid, or mRNA, vaccine contains genetic material (mRNA) that tells the body how to make a protein, which triggers an immune response to create antibodies to fight disease." Respondents were asked to indicate their level of disagreement or agreement regarding purchasing intent and consumption of beef products from cattle administered the mRNA vaccine. The question stem said, "I would…" followed by different items, such as "purchase beef products from cattle administered the mRNA vaccine for myself." The Cronbach's alpha for this construct was .97, and the index was calculated by averaging all of the scale items.

Issue involvement was measured by an 8-item, 5-point Likert-type scale that was researcher developed. For the purpose of this study, issue involvement was defined as how the administration of mRNA vaccines in beef cattle impacts people personally. The scale consisted of the following items: *1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree.* Respondents were asked to indicate which statement best represented their perspective regarding the use of mRNA vaccine technology in beef cattle. The question stem said, "The administration of mRNA vaccines in beef cattle…" followed by different statements such as, "will negatively impact my health" and "will make beef more affordable."

The Cronbach's alpha for this question was .85, and the index was calculated by averaging the scale items.

The questions related to risk perception were adapted from a previous study conducted on public understandings of risk, human health, and the use of synthetically obtained livestock vaccines (Ditlevsen et al., 2021). An 8-item, 5-point Likert-type scale was used that consisted of the same scale as purchasing intent and issue involvement. Respondents were asked to indicate their level of disagreement or agreement with the following statements. Some examples of the statements include, "I believe that consuming beef products from animals administered the mRNA vaccines could pose a risk to my health." and "The use of mRNA vaccines in beef cattle can alter their genetic makeup." Responses were coded so that a *5* indicated high perceptions of risk and a *1* indicated low perceptions of risk. The Cronbach's alpha for this item was .89, and the index was calculated by averaging the scale items.

Data Analysis

The survey data was analyzed using SPSS Version 29. Objective 1 was analyzed using descriptive statistics, including frequencies, means, and standard deviations. To aid in the interpretation of the results, real limits were established to describe the data for Likert-type scale items (Sheskin, 2004): 1.00 – 1.49 = *strongly disagree,* 1.50 – 2.49 = *disagree,* 2.50 – 3.49 = *neither agree nor disagree*, 3.50 – 4.49 = *agree*, and 4.50 – 5.00 = *strongly agree*. Real limits were also established for the bipolar semantic differential scale measuring attitude and was as follows (Sheskin, 2004): 1.00 – 1.49 = *very negative*, 1.50 – 2.49 = *negative,* 2.50 – 3.49 = *neutral,* 3.50 – 4.49 = *positive,* and 4.50 – 5.00 = *very positive*. Knowledge was transformed into a count variable based on the number of questions answered correctly. The scale ranged from zero (no knowledge) to twelve (complete knowledge).

For Objective 2, respondents were grouped into one of the following four categories of publics based on Hallahan's (2000) definition of publics in Figure 3.1: active, aware, aroused, or inactive publics. Publics were created by using methods from a previous study (Ruth et al., 2017) by first transforming the knowledge and involvement indexes into dichotomous variables based on mean scores for each construct (Issue Involvement *m* = 3.09; Knowledge *m* = 2.99). Respondents who averaged less than or equal to 3.09 on issue involvement (*SD* = 0.70) were categorized as "low issue involvement", while 3.10 or higher were categorized as "high issue involvement". Results from the survey indicated that none of the respondents had high knowledge. Due to this, knowledge was calculated relative to the sample and will be referred to as "relatively high" and "relatively low" throughout the study. Respondents who answered three or less knowledge questions correctly (*SD* = 2.22) were categorized as "relatively low" knowledge, while those who answered four or more correctly were categorized as "relatively high" knowledge. The categorical variable for publics was then created based on the newly created dichotomous variables for knowledge and issue involvement to reflect **Table 3.4**. The SPSS file was split by public categories and the researchers ran frequencies for demographics across the different groups. Objective 3 was analyzed by splitting the SPSS file by public categories and running descriptive statistics for attitudes, risk perceptions, and purchasing intent for each public.

Table 3.4. ***Categorization of Publics Based on Hallahan (2000)***

	Low Involvement (*Range: 0.00 - 3.09*)	High Involvement (*Range: 3.10 - 5.00*)
Relatively High Knowledge (*Range: 4.00 – 12.00*)	Aware Publics	Active Publics
Relatively Low Knowledge (*Range: 0.00 – 3.00*)	Inactive Publics	Aroused Publics

Results

Research Objective 1: Determine U.S. Consumers' Issue Involvement, Knowledge, Attitudes, Risk Perceptions, and Purchasing Intent Associated with the Use of the mRNA Vaccine in Beef Cattle

Table 3.5 displays issue involvement related to the administration of mRNA vaccines in beef cattle. Nearly half (47.4%) of respondents either agreed or strongly agreed that the administration of mRNA vaccines in beef cattle would increase food safety in beef. Over one-fourth (30.8%) of respondents either agreed or strongly agreed that the administration of mRNA vaccines in beef cattle would positively influence their purchasing decisions. The overall mean value for issue involvement was $M = 3.09$ ($SD = 0.70$), indicating that respondents neither agreed nor disagreed that the administration of mRNA vaccines in beef cattle was a relevant issue.

Table 3.6 displays responses to the twelve knowledge questions asked in the survey. The scale ranged from zero (no knowledge) to twelve (complete knowledge). "Vaccinations in beef cattle are mainly used for the treatment of diseases when the animal becomes ill" was a false statement, which was correctly identified by 42.0% of the respondents. The statement, "Beef producers are not required to have a veterinarian present to administer vaccines to beef cattle" was true and was correctly identified by 37.8% of the respondents. Over one-third (34.7%) of respondents correctly identified that, "Vaccines have established withdrawal periods, which is the time that must elapse between the administration of the product and the slaughtering of a food animal" was a true statement. The statement, "Food products such as steak, ground beef, roast, etc. from beef cattle that have been administered an mRNA vaccine will contain residue of the mRNA vaccine" was a false statement, which was correctly identified by 17.0% of respondents. Only 5.2% of respondents correctly answered the question that stated, "mRNA

Table 3.5. ***Issue Involvement (n = 519)***

"The administration of mRNA vaccines in beef cattle…"	Strongly Disagree (%)	Disagree (%)	Neither Disagree nor Agree (%)	Agree (%)	Strongly Agree (%)
will negatively impact my health.[a]	7.3	15.6	38.2	28.3	10.6
would increase food safety in beef.	7.3	8.9	36.4	38.2	9.2
leads to safer beef products.	7.5	7.3	40.8	35.3	9.1
will decrease the quality of beef products.[a]	8.1	16.2	38.9	28.1	8.7
will positively influence my purchasing decisions.	5.6	15.0	48.6	22.7	8.1
would increase beef availability for myself.	8.5	15.0	48.9	22.4	5.2
causes me concern.[a]	13.7	31.4	29.1	20.6	5.2
will make beef more affordable.	9.1	20.8	47.4	18.1	4.6

[a]Reverse coded

Table 3.6. ***Knowledge (n = 519)***

Statement	A	C (%)	I (%)	DK (%)
Vaccinations in beef cattle are mainly used for the treatment of disease when the animal becomes ill.	F	42.0	25.0	33.0
Beef producers are not required to have a veterinarian present to administer vaccines to beef cattle.	T	37.8	15.2	47.0
Vaccines have established withdrawal periods, which is the time that must elapse between the administration of the product and the slaughtering of a food animal.	T	34.7	6.0	59.3
The vaccine technologies present in beef cattle vaccinations are listed on the vaccine label.	T	31.8	11.6	56.6
The administration of a mRNA vaccine to beef cattle can alter the genetic makeup of its meat.	F	28.3	20.8	50.9
mRNA vaccines are used in beef cattle to help prevent the spread of COVID-19.	F	27.7	18.7	53.6

Table 3.6. ***Knowledge (n = 519) cont.***

Statement	A	C (%)	I (%)	DK (%)
Currently, there is no federal requirement for beef cattle to receive vaccinations.	T	24.7	17.9	57.4
The vaccine technologies used on beef cattle are required to be listed on a food product label.	F	24.3	23.3	52.4
Beef producers can purchase vaccines without a prescription from a veterinarian.	T	21.2	21.4	57.4
Food products such as steak, ground beef, roast, etc. from beef cattle that have been administered an mRNA vaccine will contain residue of the mRNA vaccine.	F	17.0	28.3	54.7
mRNA vaccines have been approved by the USDA and FDA for use in cattle, sheep, goats, and swine in the United States.	F	5.2	42.2	52.6

Table 3.6. ***Knowledge (n = 519) cont.***

Statement	A	C (%)	I (%)	DK (%)
The Center for Veterinary Medicine (CVM) tests new animal drugs for safety and effectiveness.	F	4.6	58.6	36.8

Note. A = answer; C = correct; I = incorrect; DK = don't know

vaccines have been approved by the USDA and FDA for use in cattle, sheep, goats, and swine in the United States," which was a false statement. Lastly, only 4.6% of respondents correctly identified that the statement, "The Center for Veterinary Medicine (CVM) tests new animal drugs for safety and effectiveness" was false. For nine of the twelve questions, at least half of the respondents did not know the answer to the question. On average, respondents answered 2.99 (*SD* = 2.22) out of 12 questions correct.

Respondents' attitudes toward the purchase and consumption of beef from cattle administered mRNA vaccines is displayed in **Table 3.7**. The grand mean for attitudes was *M* = 2.79 (*SD* = 1.04), suggesting respondents had neutral attitudes toward purchasing and consuming beef from cattle administered mRNA vaccines.

Respondents' risk perceptions regarding the use of mRNA vaccines in beef cattle are found in **Table 3.8**. Approximately half (51.3%) of respondents either agreed or strongly agreed they were concerned of beef cattle diseases that were contagious to them. A considerable percentage (42.0%) of respondents either agreed or strongly agreed they were concerned there were unknown health impacts associated with the consumption of beef products from animals administered the mRNA vaccine. However, 41.6% of respondents either disagreed or strongly disagreed that beef cattle's health was at risk when administered mRNA vaccines. Additionally, approximately forty percent (43.0%) of respondents neither agreed nor disagreed that the use of mRNA vaccines in beef cattle can alter their genetic makeup. The overall mean for risk perception was *M* = 3.05 (*SD* = 0.79), indicating respondents neither agreed nor disagreed that there was risk associated with the use of the mRNA vaccine in beef cattle.

Table 3.7. ***Attitudes – Purchasing and Consumption of Beef (n = 519)***

"Purchasing and consuming beef from cattle administered a mRNA vaccine is…"	*M*	SD
Crucial/Trivial[a]	2.86	1.17
Necessary/Unnecessary[a]	2.85	1.24
Not Beneficial/Beneficial	2.84	1.26
Not Essential/Essential	2.81	1.25
Negative/Positive	2.81	1.24
Good/Bad[a]	2.77	1.23
Acceptable/Unacceptable[a]	2.75	1.23
Unimportant/Important	2.68	1.18
Scale Average	2.79	1.04

[a]Reverse coded

Table 3.8. ***Risk Perceptions (n = 519)***

Statement	Strongly Disagree (%)	Disagree (%)	Neither Disagree nor Agree (%)	Agree (%)	Strongly Agree (%)
I am concerned of beef cattle diseases that could be contagious to me.	4.8	13.3	30.6	37.6	13.7
I am concerned there are unknown health impacts associated with the consumption of beef products from animals administered the mRNA vaccine.	5.8	16.6	35.6	29.1	12.9
I am skeptical of new vaccine technologies that are created for beef cattle.	6.9	21.0	33.9	26.8	11.4
I believe there will be residue of the mRNA vaccine in the products I consume from beef cattle administered the mRNA vaccines.	6.0	16.9	39.9	26.0	11.2
I believe that consuming beef products from animals administered the mRNA vaccines could pose a risk to my health.	8.7	28.7	32.0	20.6	10.0
The use of mRNA vaccines in beef cattle can alter their genetic makeup.	7.9	20.6	43.0	19.5	9.0

Table 3.8. ***Risk Perceptions (n = 519) cont.***

Statement	Strongly Disagree (%)	Disagree (%)	Neither Disagree nor Agree (%)	Agree (%)	Strongly Agree (%)
I believe that beef cattle's health is at risk whey they are administered mRNA vaccines.	10.8	30.8	34.1	16.2	8.1
I believe that mRNA vaccines could serve as a useful tool for disease management in beef cattle.[a]	11.1	40.8	33.1	7.5	7.5

[a]Reverse coded

Respondents' intent to purchase beef administered the mRNA vaccine is displayed in **Table 3.9**. When asked if respondents would purchase beef products from cattle administered the mRNA vaccine for friends and family, 46.5% either agreed or strongly agreed that they would. Similarly, almost half (47.8%) of respondents either agreed or strongly agreed they would purchase beef products from cattle administered the mRNA vaccine for themselves. The average for purchasing intent was $M = 3.24$ ($SD = 1.05$), indicating respondents neither agreed nor disagreed that they would purchase beef from cattle administered the mRNA vaccine.

Table 3.10 displays the grand means for all measurements pertaining to Objective 1. Respondents neither agreed nor disagreed that the mRNA vaccine in beef cattle was an issue ($M = 3.09$; $SD = 0.70$). On average, respondents answered 2.99 ($SD = 2.22$) out of the twelve knowledge questions correctly. Respondents held neutral attitudes toward the use of mRNA vaccines in beef cattle ($M = 2.79$; $SD = 1.04$) and neither agreed nor disagreed that there was risk associated with the administration of mRNA vaccines in beef cattle ($M = 3.05$; $SD = 0.79$). Lastly, respondents neither agreed nor disagreed that they would purchase beef from cattle administered the mRNA vaccine ($M = 3.24$; $SD = 1.05$).

Research Objective 2: Define the Types of Publics in Relation to the Use of the mRNA Vaccine in Beef Cattle Based on Issue Involvement and Knowledge

Respondents were grouped into one of four publics based on responses to the survey questions about issue involvement and knowledge related to the use of mRNA vaccines in beef cattle. Issue involvement and knowledge were divided into relatively high and low categories based on the means described in Table 3.10. The distribution of publics in this sample along with the average issue involvement and knowledge per public has been described in **Table 3.11**.

Table 3.9. ***Purchasing Intent (n = 519)***

"I would..."	Strongly Disagree (%)	Disagree (%)	Neither Disagree nor Agree (%)	Agree (%)	Strongly Agree (%)
offer beef products from cattle administered the mRNA vaccine to friends and family.	10.4	10.0	35.6	34.9	9.1
purchase beef products from cattle administered the mRNA vaccine for my friends and family.	11.7	10.4	31.4	37.8	8.7
consume beef products from cattle administered the mRNA vaccine.	10.6	10.2	28.5	42.4	8.3
purchase beef products from cattle administered the mRNA vaccine for myself.	11.5	8.5	32.2	39.7	8.1

Table 3.10. ***Indexes for all Measurements (n = 519)***

Category	*M (SD)*
Issue Involvement[a]	3.09 (0.70)
Knowledge[b]	2.99 (2.22)
Attitudes[a]	2.79 (1.04)
Risk Perceptions[a]	3.05 (0.79)
Purchasing Intent[a]	3.24 (1.05)

[a]Scale range of 1-5
[b]Scale range of 0-12

Table 3.11. ***Public Groups Based on Issue Involvement and Knowledge (n = 519)***

Category	Active (*n* = 123) *M (SD)*	Aware (*n* = 80) *M (SD)*	Aroused (*n* = 141) *M (SD)*	Inactive (*n* =175) *M (SD)*
Issue Involvement[a]	3.67 (0.42)	2.41 (0.55)	3.53 (0.39)	2.63 (0.51)
Knowledge[b]	5.39 (1.31)	5.06 (1.44)	1.79 (1.14)	1.32 (1.19)
% of Sample	23.7%	15.4%	27.2%	33.7%

[a]Scale range of 1-5
[b]Scale range of 0-12

Over one-third (33.7%, n = 175) of the respondents belonged to the inactive public. The inactive publics possessed low issue involvement (M = 2.63; SD = 0.51) and relatively low knowledge (M = 1.32; SD = 1.19). Over one-fourth (27.2%; n = 141) were categorized as an aroused public. The aroused publics possessed high issue involvement (M = 3.53; SD = 0.39) and relatively low knowledge (M = 1.79; SD = 1.14). The smallest publics category was aware publics (15.4%; n = 80). The aware publics possessed low issue involvement (M = 2.41; SD = 0.55) and relatively high knowledge (M = 5.06; SD = 1.44). Less than one-fourth (23.7%; n = 123) of respondents were considered to be an active public. The active publics possessed high issue involvement (M = 3.67; SD = 0.42) and relatively high knowledge (M = 5.39; SD = 1.31).

Description of Publics

Table 3.12 displays the demographic characteristics for each group of publics. Approximately one-fifth (20.3%) of the respondents in the active group were 25-44 years old. Respondents who were 25-44 years old made up 15.0% of the aware group, 14.2% of the aroused group, and 10.9% of the inactive group. The active group had the largest proportion of males (46.3%), followed by the aroused group (30.5%), the aware group (27.5%), and the inactive group (27.4%), respectfully. Nearly one-fourth (24.4%) of the respondents in the active group had attended graduate or professional school. This can be compared to the respondents who hold graduate or professional degrees in the aroused (17.0%), aware (12.5%), and inactive (8.0%) groups. Most of the respondents' income stemmed from a non-farming household, with all (100%) of the inactive respondents' income source being a non-farming household. Approximately one-third (32.5%) of respondents in the aware group are from a rural area. The largest proportion of respondents who considered themselves to be "very conservative" were in

Table 3.12. ***Respondent Demographics by Public Groups (n = 519)***

	Active	Aware	Aroused	Inactive
	(*n* = 123)	(*n* = 80)	(*n* = 141)	(*n* = 175)
	%	*%*	*%*	*%*
Age				
18-24	0.8	2.5	0.7	1.7
25-44	20.3	15.0	14.2	10.9
45-64	21.2	21.2	32.6	33.1
65+	57.7	61.3	52.5	54.3
Gender				
Female	53.7	72.5	68.1	72.0
Male	46.3	27.5	30.5	27.4
Other	0.0	0.0	1.4	0.6
Race/Ethnicity				
White	80.5	85.0	83.7	81.7
African American	13.8	11.3	11.3	12.6
Hispanic	5.7	5.0	5.7	2.3
Other	4.1	0.0	4.2	5.7

Table 3.12. ***Respondents Demographics by Public Groups (n = 519) cont.***

	Active (n = 123) %	Aware (n = 80) %	Aroused (n = 141) %	Inactive (n = 175) %
Education				
High School or less	19.5	26.2	26.2	26.9
Some College	25.2	33.7	19.9	29.1
2-year College Degree	10.6	11.3	11.4	20.6
4-year College Degree	20.3	16.3	25.5	15.4
Graduate or Professional School	24.4	12.5	17.0	8.0
Income				
Less than $25,000	19.5	17.5	20.6	24.0
$25,000 - $49,999	26.0	33.7	31.2	30.3
$50,000 - $99,999	32.5	26.2	31.9	32.6
$100,000 - $149,999	15.5	13.8	10.6	6.8
$150,000 or more	6.5	8.8	5.7	6.3
Income Source				
Farming household	7.3	8.7	1.4	0.0
Non-farming household	92.7	91.3	98.6	100.0

Table 3.12. ***Respondents Demographics by Public Groups (n = 519) cont.***

	Active	Aware	Aroused	Inactive
	(*n* = 123)	(*n* = 80)	(*n* = 141)	(*n* = 175)
	%	*%*	*%*	*%*
Political Affiliation				
Very Liberal	15.5	8.7	14.9	2.3
Liberal	26.0	13.8	19.1	15.4
Moderate	32.5	37.5	45.4	44.0
Conservative	17.1	22.5	13.5	23.4
Very Conservative	8.9	17.5	7.1	14.9
Location				
Urban	26.8	22.5	28.4	21.1
Rural	26.8	32.5	18.4	22.3
Suburban	46.4	45.0	53.2	56.6
Children in Home	17.9	16.3	19.1	11.4

the aware group (17.5%), followed by the inactive (14.9%), active (8.9%), and aroused (7.1%) groups, respectfully.

Table 3.13 displays the most common social media applications used across the groups of publics. Facebook was the most common social media application used, with the aware group being the largest users of Facebook (82.5%). YouTube was the second most common social media application used, with the active group being the largest users of YouTube (65.0%).

Research Objective 3: Compare U.S. Consumers' Attitudes, Risk Perceptions, and Purchasing Intent Related to the Use of the mRNA Vaccine in Beef Cattle Across Identified Groups of Publics

Table 3.14 displays each public group's perceptions of attitude, risk perceptions, and purchasing intent for beef products from cattle administered mRNA vaccines. The inactive publics (low issue involvement/relatively low knowledge) had neutral attitudes (M = 3.29; SD = 0.92), neither agreed nor disagreed that there was risk associated with mRNA vaccines in beef cattle (M = 3.46; SD = 0.61), and neither agreed nor disagreed that they would purchase and consume beef administered the mRNA vaccine (M = 2.59; SD = 0.88). The aroused publics (high issue involvement/relatively low knowledge) had negative attitudes (M = 2.32; SD = 0.80), neither agreed nor disagreed that there was risk associated with mRNA vaccines in beef cattle (M = 2.70; SD = 0.61), and agreed they would purchase and consume beef administered the mRNA vaccine (M = 3.83; SD = 0.61). The aware publics (low issue involvement/relatively high knowledge) had neutral attitudes (M = 3.43; SD = 0.92), neither agreed nor disagreed that there is risk associated with mRNA vaccines in beef cattle (M = 3.48; SD = 0.79), and disagreed that they would purchase and consume beef administered the mRNA vaccine (M = 2.39; SD = 1.05). The active publics (high issue involvement/relatively high knowledge) had negative attitudes (M

Table 3.13. ***Social Media Applications Used by Respondents by Public Groups (n = 519)***

	Active (n = 123) %	Aware (n = 80) %	Aroused (n = 141) %	Inactive (n = 175) %
Facebook	70.7	82.5	74.5	78.3
Twitter	22.8	17.5	19.9	15.4
Instagram	35.0	38.8	34.8	29.7
Snapchat	16.3	13.8	11.3	8.6
YouTube	65.0	61.3	62.4	56.6
Reddit	17.1	12.5	12.8	9.7
Pinterest	24.4	26.3	22.0	20.0
TikTok	18.7	28.7	28.4	19.4
Other	4.1	1.3	4.3	4.6
None	13.0	6.3	11.3	6.9

Note. Respondents were asked to select social media applications they used at least once a week in a check-all-that-apply format.

Table 3.14. ***Public Groups Based on Attitudes, Risk Perceptions, and Purchasing Intent (n = 519)***

Index Category	Active (*n* = 123) *M (SD)*	Aware (*n* = 80) *M (SD)*	Aroused (*n* = 141) *M (SD)*	Inactive (*n* =175) *M (SD)*
Attitudes	2.21 (0.93)	3.43 (0.92)	2.32 (0.80)	3.29 (0.92)
Risk Perceptions	2.57 (0.75)	3.48 (0.79)	2.70 (0.61)	3.46 (0.61)
Purchasing Intent	4.03 (0.61)	2.39 (1.05)	3.83 (0.61)	2.59 (0.88)

= 2.21; *SD* = 0.93), neither agreed nor disagreed that there is risk associated with mRNA vaccines in beef cattle (*M* = 2.57; *SD* = 0.75), and agreed that they would purchase and consume beef administered the mRNA vaccine (*M* = 4.03; *SD* = 0.61).

Conclusions, Implications, and Recommendations

The purpose of this study was to develop audience segmentations of different publics across the United States regarding perceptions of mRNA vaccines in beef cattle. Consumers' opinions could limit the application of mRNA vaccines in beef cattle (Scudamore, 2007); however, their opinions may not always be grounded in factual information (Rhodes, 2022). While one limitation of this study was that at the time of the research no mRNA vaccines had been approved for use in livestock (Strickland, 2023), being proactive on this topic and understanding the types of publics related to the mRNA vaccines can allow agricultural communicators to create effective, strategic communications that allow consumers to form attitudes and make decisions grounded in factual information.

Overall, respondents provided neutral responses for all variables of interest aside from knowledge. Respondents neither agreed nor disagreed that mRNA vaccines in beef cattle were a relevant issue. While some respondents correctly answered more knowledge questions related to mRNA vaccines in beef cattle compared to others, knowledge was considerably low. Results indicated respondents were more knowledgeable of general livestock vaccine protocols compared to the mRNA vaccine technology in livestock and its availability. For example, only 5.2% of respondents knew that mRNA vaccines had not been approved for use in the United States. Respondents' lack of knowledge related to mRNA vaccines in livestock corresponds to the misleading information that has been posted on social media platforms by consumers (Frank, 2023; Lazy J Meats, 2024; Renz, 2023). Agriculture communicators should focus on providing

factual information related to mRNA vaccines in beef cattle to consumers to enhance their knowledge, particularly on social media, due to consumers' engagement in filter bubbles and echo chambers (Rhodes, 2022). Information could be distributed on Facebook, YouTube, and Instagram, as these were the most common platforms used by respondents.

On average, respondents in this study demonstrated neutral attitudes regarding purchasing and consuming beef from cattle administered a mRNA vaccine. These findings indicated strong attitudes had not yet formed related to the use of mRNA vaccines in beef cattle, thus providing the industry the opportunity to take a proactive approach to encourage acceptance if these vaccines are approved in the future. Lastly, respondents, on average, neither agreed nor disagreed that there was risk associated with the use of mRNA vaccines in beef cattle. Similarly, on average, respondents neither agreed nor disagreed that they would purchase and/or consume beef from cattle that had been administered the mRNA vaccine.

Based on the results and Hallahan's (2000) categorization of publics, the largest group of publics in this study was the inactive public (low issue involvement/relatively low knowledge), and the smallest group was the aware public (low issue involvement/relatively high knowledge). Previous research that used audience segmentation to determine consumers' perceptions of novel agriculture technologies also identified the inactive group as the largest group of publics (Burke et al., 2020). However, compared to previous research that have used audience segmentation on current agriculture issues (Burke et al., 2020; Ruth et al., 2017), the mRNA vaccine has not been approved for use in livestock at the time of this study (Strickland, 2023). This could serve as a limitation of this study and account for the large proportion of inactive publics due to low issue involvement and relatively low knowledge. **Table 3.15** provides an overview of each public category along with communication recommendations.

Table 3.15. ***Overview of Publics***

Public	Characterization	Communication Recommendations
Active (23.7%)	High Issue Involvement/ Relatively High Knowledge	This group holds negative attitudes toward purchasing and consuming beef administered the mRNA vaccine. However, they neither agree nor disagree that there is risk associated with the use of the mRNA vaccine in beef cattle and agree they would purchase and consume beef from cattle administered the mRNA vaccine. Agriculture practitioners should acknowledge, support, engage with, and negotiate with these publics.
Aware (15.4%)	Low Issue Involvement/ Relatively High Knowledge	This group holds neutral attitudes toward purchasing and consuming beef administered the mRNA vaccine. They neither agree nor disagree that there is risk associated with the use of the mRNA vaccine in beef cattle but disagree that they would purchase and consume beef from cattle administered the mRNA vaccine. Agriculture practitioners should monitor these publics as they could influence opinions.

Table 3.15. ***Overview of Publics cont.***

Public	Characterization	Communication Recommendations
Aroused (27.2%)	High Issue Involvement/ Relatively Low Knowledge	This group holds negative attitudes toward purchasing and consuming beef administered the mRNA vaccine. However, they neither agree nor disagree that there is risk associated with the use of the mRNA vaccine in beef cattle and agree that they would purchase and consume beef from cattle administered the mRNA vaccine. Agriculture practitioners should provide factual information to these publics.
Inactive (33.7%)	Low Issue Involvement/ Relatively Low Knowledge	This group holds neutral attitudes toward purchasing and consuming beef administered the mRNA vaccine. They neither agree nor disagree that there is risk associated with use of the mRNA vaccine in beef cattle and neither agree nor disagree that they would purchase and consume beef from cattle administered the mRNA vaccine. Agriculture practitioners should seek out these publics first and develop relationships with them.

The inactive publics (low issue involvement/relatively low knowledge) had neutral attitudes, neither agreed nor disagreed that there was risk associated with the use of mRNA vaccines in beef cattle, and neither agreed nor disagreed that they would purchase and consume beef from cattle administered the mRNA vaccine. Based on Hallahan's (2000) communication recommendations, these publics should not merely be ignored. Inactive publics are unlikely to seek information regarding mRNA vaccines themselves (Hallahan, 2000). Therefore, it will be the responsibility of agriculture communicators and Extension specialists to seek out these publics and create relationships with them (Hallahan, 2000). Recommendations include seeking out inactive publics first as they are the largest group of publics and there is an opportunity to influence their perceptions of the mRNA vaccine before it is approved for use. It could be beneficial for agriculture communicators and Extension specialist to begin by educating inactive publics about vaccines in livestock before focusing specifically on mRNA vaccines. For example, while 17.0% of respondents correctly identified that beef will not contain residue of the mRNA vaccine, only 34.7% of respondents knew that there are established withdrawal periods for food-producing animals. In addition, respondents believe there could be unknown health impacts associated with the consumption of beef from animals that have been administered the mRNA vaccine. Education focusing on broader concepts of livestock vaccines first may allow the public to better understand the science behind mRNA vaccines.

The aware public (low issue involvement/ relatively high knowledge) had neutral attitudes, neither agreed nor disagreed that there was risk associated with the use of mRNA vaccines in beef cattle, and indicated they would not likely purchase and consume beef from cattle administered the mRNA vaccine. Individuals in the aware group have been known to influence the opinions of others (Hallahan, 2000). While aware publics are the smallest group of

publics in relation to mRNA vaccines in beef cattle, agriculture communicators and Extension specialists should monitor the behaviors of these publics (Hallahan, 2000). These publics could serve as advocates for the mRNA vaccine in beef cattle. However, they could contribute to the spread of misinformation of mRNA vaccines in beef cattle if concerns related to intent to purchase are not addressed (Rhodes, 2022; Wu et al., 2019). More research with this public is needed to understand what is influencing purchasing intent.

Both the aroused publics (high issue involvement/relatively low knowledge) and the active public (high issue involvement/relatively high knowledge) had negative attitudes, neither agreed nor disagreed that there was risk associated with the use of mRNA vaccines in beef cattle, and agreed they would purchase and consume beef from cattle administered the mRNA vaccine. Aroused publics often seek out information to reduce uncertainty (Hallahan, 2000), so agriculture communicators and Extension specialists should take that opportunity to provide them with factual information regarding the mRNA vaccine technology. Agriculture practitioners should seek to understand why individuals in the aroused public have taken interest in mRNA vaccines in beef cattle, but why that interest has not translated to knowledge. When working with the active public, agriculture communications and Extension specialists should acknowledge, support, and engage with the active public to strengthen relationships with this group (Hallahan, 2000).

For both the active and aroused publics, additional research is needed to understand the seemingly contradictory nature of their negative attitudes and positive purchasing intent for beef products administered mRNA vaccines. Future research could compare consumers' perceptions and their willingness-to-pay for beef administered the mRNA vaccine to further evaluate this contradictory nature. The negative attitudes held by the active and aroused publics could be

related to their perceptions of the COVID-19 mRNA vaccine used in humans, which should be explored further in future research. Respondents were presented with a definition for mRNA vaccines before the questions related to risk perception and purchasing intent. However, they were not exposed to the definition before asking about their attitude. The definition may have positively informed perceptions of issue involvement, risk, and purchasing intent. This may explain the contradictory findings. In addition, the risk perception construct consisted of questions related to both risk to humans and animals. Separating these risks may yield a more nuanced understanding of perceptions of risk. Future research should explore active and aroused public's risk perceptions, attitudes, purchasing intent, and issue involvement using qualitative methods for a more in-depth understanding of their views of mRNA vaccines in beef cattle.

Future research should replicate this study by determining public groups based on issue involvement and knowledge if the mRNA vaccine was to be approved in livestock. Additionally, future research should use a qualitative study to gain further insight into consumers' issue involvement, knowledge, attitudes, risk perceptions, and purchasing intent related to mRNA vaccine use in beef cattle. Lastly, future research could consider message testing to determine the best ways to communicate information about mRNA vaccines in beef cattle to consumers, particularly consumers in each public category.

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CHAPTER 4

CONCLUSION

Overview

In response to public concern regarding the use of the mRNA vaccine technology in livestock, the purpose of this research was to explore consumers' and producers' perceptions and behaviors regarding the use of mRNA vaccines in beef cattle. Two research studies were conducted to fulfill this purpose, a qualitative and a quantitative study, to have a comprehensive understanding of the research problem (Moustakas, 1994). The qualitative study explored East Tennessee, direct-to-consumer beef producers' awareness of the mRNA vaccine in beef cattle and examined the factors that could influence their decision to adopt the novel vaccine technology on their operations in the future, if the mRNA vaccine is approved by the FDA. The aim of the quantitative study was to identify and understand the types of publics in the United States and their perceptions of the use of mRNA vaccines in beef cattle.

Study #1

In-depth, one-on-one interviews with seven (n = 7) direct to-consumer East Tennessee beef producers were conducted for the qualitative study. Participants were recruited from the *Spring 2023 – Spring 2024 East Tennessee Local Food Guide* (Nourish Knoxville, 2023). Participants were recruited via phone and email and incentivized through $100. The interviews were conducted in fall of 2023 via phone. A semi-structured interview guide (Appendix B), that consisted of five sections and approximately 40 questions/discussion points, was used to facilitate the discussion and provide the researchers with flexibility to ask follow-up questions (Morse, 2015). Two researchers were present for each interview and member-checking was

conducted at the end of each interview (Creswell, 2005; Lincoln & Guba, 1985). The interviews were recorded via Zoom and were transcribed using a 3rd party.

The interview transcripts were uploaded to NVivo for coding. A codebook was established prior to the data analysis using deductive methods (Bingham & Witkowsky, 2022), with some emerging codes added throughout. The creation of the codebook was guided by the Theory of Planned Behavior (TPB; Ajzen, 1991). We used TPB to evaluate how attitudes, subjective norms, perceived behavioral control, and knowledge impacted participants' intent to implement mRNA vaccines in their operations in East Tennessee in the future. Knowledge was included as an additional measurement as past research has found it to influence livestock producers' decision-making process (Alarcon et al., 2014; Bhujel & Joshi, 2023; Delgado, 2012; Garforth et al., 2013; Kramer et al., 2017). The final codebook consisted of 18 codes, with each code having a definition and an example. Subjectivity of the two researchers were considered during the coding process and data analysis. One researcher had an extensive background in qualitative research and sustainable agriculture, while the other researcher had limited qualitative research experience but an extensive background in beef production. The two researchers coded each interview separately and then reconvened to confirm final codes. Once all the transcripts were coded, the researchers worked together to generate themes. The findings were confirmed by comparing to the TPB (Ajzen, 1991) and the audit trail (Carter et al., 2014).

Study #2

A national, online Qualtrics survey (Appendix D) with 519 respondents was conducted for the quantitative study. The population of interest was U.S. residents who had purchased and/or consumed beef in the previous 6 months at the time of the survey. Non-probability quota sampling was used, by requesting for Qualtrics to implement quotas that matched the U.S.

Census for age, gender, race, and ethnicity, to reduce bias when generalizing findings to the entire population (Baker et al., 2013). However, some of the quotas were relaxed, causing some of the sample to skew from the population identified in the U.S. census. Screening questions were asked at the beginning of the survey to ensure respondents were meeting the parameters set of the quota. Before distribution, the survey was reviewed by a panel of experts (Ary et al., 2010), the instrument was piloted, cognitive interviews were conducted, and the survey was soft launched to ensure it was working as expected. Five survey constructs related to mRNA and cattle were analyzed for this study: attitudes, knowledge, purchasing intent, issue involvement, and risk perceptions (Appendix E). Attitude was measured using an 8-item, 5-point bipolar semantic differential scale that used adjectives that were antonyms to evaluate respondents' feelings toward the administration of mRNA vaccines in beef cattle. Twelve questions, that allowed respondents to answer *True*, *False*, or *I don't know*, were asked to measure knowledge of mRNA vaccines in beef cattle. Purchasing intent was measured using a 4-item, 5-point Likert-type scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*. The issue involvement and the risk perception construct were measured using two separate 8-item, 5-point Likert-type scales that used the same labels as purchasing intent. Data was analyzed using SPSS Version 29. Descriptive statistics, including frequencies, means, and standard deviations, were used for Objective 1. To interpret the results, real limits were established for the Likert-type scale items and the bipolar semantic differential scale (Sheskin, 2004). Knowledge was converted to a count variable based on the number of correctly answered questions, which ranged from 0 (no knowledge) to twelve (complete knowledge). For Objective 2, respondents were grouped into four groups based on issue involvement and knowledge: aware, active, aroused, and inactive. These categories were based on the Situational Theory of Publics (Grunig, 1983) and the Five

Publics Model Based on Knowledge and Involvement (Hallahan, 2000). The SPSS file was split, and frequencies were ran for demographics of each public category. For Objective 3, the SPSS file was split by public categories and descriptive statistics were used for attitudes, risk perceptions, and purchasing intent.

Overview of Findings

The qualitative study evaluated direct-to-consumer beef producers' future intent to implement mRNA vaccines in their operations in East Tennessee using the Theory of Planned Behavior (TPB; Ajzen, 1991). Using TPB, participants' weak attitudes of mRNA vaccines in beef cattle, perceived negative subjective norms from consumers, and absence of perceived behavioral control, likely due to the mRNA vaccine not being approved for use at the time of the study, would likely lead to low behavioral intent to use mRNA vaccines on their beef cattle operations in the future (Ajzen, 1991). The participants exhibited low knowledge, which was an additional measurement included in this study, regarding mRNA vaccines in livestock. Knowledge likely influenced participants' attitudes and appeared to indirectly impact behavioral intent. The quantitative study aimed to identify and understand the types of publics in the United States and their perceptions of mRNA vaccines in beef cattle. Overall, respondents provided neutral responses for issue involvement, attitudes, risk perceptions, and purchasing intent related to mRNA vaccines in beef cattle. Respondents' knowledge of mRNA vaccines were generally low. Respondents were grouped into four categories of publics (Hallahan, 2000): active (high issue involvement/relatively high knowledge), aware (low issue involvement/relatively high knowledge), aroused (high issue involvement/relatively low knowledge), and inactive (low issue involvement/relatively low knowledge). Risk perceptions across the publics remained neutral. However, attitudes across publics varied from negative to neutral, and publics expressed

different levels of agreement regarding their intent to purchase beef administered mRNA vaccines in the future.

Summary of Results, Discussion, and Implications

This summary covers the research questions/objectives from both the qualitative and quantitative studies, along with a discussion of the synthesis of findings and their implications.

Study #1: A Qualitative Exploration of Tennessee Direct-to-Consumer Beef Producers' Perspectives of mRNA Vaccines

This study used qualitative methods to answer two research questions. They key findings for each research question have been summarized below.

RQ1: What are East Tennessee direct-to-consumer beef producers' current practices related to vaccine and antibiotic use in their cattle production?

Participants expressed negative, neutral, and positive opinions about general livestock vaccines. Some participants described using vaccines to prevent diseases on their operations. These producers believed using vaccines were both economically beneficial and protected animal health. On the other hand, some participants did not administer vaccines on their operations. These participants generally had smaller cattle herds and were either content with their herd's health or used different programs to manage diseases. Customer interactions also influenced participants' decision to use vaccines. Participants who administered vaccines indicated their consumers were supportive of their vaccine programs, while participants who did not administer vaccines indicated that was their consumers' preference. All but one of the participants in this study mentioned the use of animal antibiotics on their operations. Participants shared similar opinions of only using antibiotics when the animal was sick and acknowledged the importance of protecting human health when administering antibiotics.

RQ2: What are East Tennessee direct-to-consumer beef producers' perceptions toward mRNA vaccines?

Participants' perceptions toward mRNA vaccines in beef cattle were examined using the Theory of Planned Behavior (Ajzen, 1991), with the addition of knowledge. Most participants indicated they were aware of the mRNA vaccine, but their amount of knowledge of the vaccine technology did not go beyond awareness. Lack of knowledge appeared to be linked to participants' low intent to implement mRNA vaccines in the future, which aligns with past research (Alarcon et al., 2014; Delgado et al., 2012; Ellis-Iverson et al., 2010; Garforth et al., 2013). Participants held weak attitudes toward mRNA vaccines in livestock. Some participants did not see any additional benefits of the novel vaccine technology, which is contradictory to the potential benefits that have been identified through research (Gote et al., 2023; Indiana Farm Bureau, 2023; Rosa et al., 2021). Some participants indicated they could not form an attitude of the mRNA vaccine because they do not have enough information to form an opinion. Other participants demonstrated opposing views. One participant believed the vaccine could be a beneficial tool to the livestock industry while another producer absolutely opposed the mRNA vaccine. Most participants explained how they had negative interactions with their customers related to the administration of the mRNA vaccine in beef cattle, which aligns with discussions that are evolving on the media (Frank, 2023). Some producers indicated they would most likely lose business if they decided to implement mRNA vaccines on their operation in the future. Perceived behavioral control did not emerge as a theme during the analysis due to the mRNA vaccine not being approved for use at the time of the study. Participants' weak attitudes, which was found to be influenced by low knowledge, perceived negative subjective norms, and lack of

perceived behavioral control will likely lead to producers' low behavioral intent to implement mRNA vaccines on their operations in the future (Ajzen, 1991).

Study #2: A Quantitative Analysis of United States Consumers' Perspectives of mRNA Vaccines in Beef Cattle

Study #2 used quantitative methods to fulfill the purpose through three objectives. A summary of key findings for each objective is described below.

Obj. 1: Determine U.S. consumers' issue involvement, knowledge, attitudes, risk perceptions, and purchasing intent associated with the use of the mRNA vaccine in beef cattle

Overall, respondents provided neutral responses to all variables of interest, excluding knowledge. Regarding issue involvement, respondents neither agreed nor disagreed that the administration of mRNA vaccines in beef cattle was a relevant issue (M = 3.09, SD = 0.70). Knowledge related to mRNA vaccines in beef cattle were considerably low, with respondents correctly answering, on average, 2.99 (SD = 2.22) out of 12 questions correct. For nine of the twelve questions, at least half of the respondents did not know the answer to the question. The findings revealed that respondents were more familiar with general vaccine protocols compared to the mRNA vaccine technology and its availability. The general lack of knowledge in respondents represents the misleading information that has been seen on social media platforms (Frank, 2023; Lazy J Meats, 2024; Renz, 2023). Respondents' answers to the attitude construct suggested overall neutral attitudes towards purchasing and consuming beef from cattle administered mRNA vaccines (M = 2.79; SD = 1.04), indicating strong attitudes have not developed and there is an opportunity for the industry to be proactive and encourage acceptance of mRNA vaccines. Regarding risk perceptions, respondents neither agreed nor disagreed that there was risk associated with the use of the mRNA vaccine in beef cattle (M = 3.05; SD = 0.79).

Lastly, respondents neither agreed nor disagreed that they would purchase beef from cattle that had been administered the mRNA vaccine (M = 3.24; SD = 1.05).

Obj. 2: Define the types of publics in relation to the use of the mRNA vaccine in beef cattle based on issue involvement and knowledge

Respondents were categorized into four categories of publics based on issue involvement and knowledge: active publics (high issue involvement/relatively high knowledge), aware publics (low issue involvement/relatively high knowledge), aroused publics (high issue involvement/relatively low knowledge), and inactive publics (low issue involvement/relatively low knowledge) (Hallahan, 2000). The largest group was the inactive publics (33.7%), followed by aroused publics (27.2%), active publics (23.7%), and aware publics (15.4%), which aligns with prior audience segmentation research that identified the inactive group as the largest group (Burke et al., 2020). Demographic characteristics and use of social media applications were compared across all publics.

Obj. 3: Compare U.S. consumers' attitudes, risk perceptions, and purchasing intent related to the use of the mRNA vaccine in beef cattle across identified groups of publics

Respondents' attitudes, risk perceptions, and purchasing intent were compared across the different groups of publics. The inactive publics (low issue involvement/relatively low knowledge) had neutral attitudes (M = 3.29; SD = 0.92), neither agreed nor disagreed that there was risk associated with mRNA vaccines in beef cattle (M = 3.46; SD = 0.61), and neither agreed nor disagreed that they would purchase and consume beef administered the mRNA vaccine (M = 2.59; SD = 0.88). The aroused publics (high issue involvement/relatively low knowledge) had negative attitudes (M = 2.32; SD = 0.80), neither agreed nor disagreed that there was risk associated with mRNA vaccines in beef cattle (M = 2.70; SD = 0.61), and agreed they would

purchase and consume beef administered the mRNA vaccine (*M* = 3.83; *SD* = 0.61). Both the inactive publics and the aroused publics are likely to seek out more information about the mRNA vaccines in beef cattle in the future (Hallahan, 200). The aware publics (low issue involvement/relatively high knowledge) had neutral attitudes (*M* = 3.43; *SD* = 0.92), neither agreed nor disagreed that there is risk associated with mRNA vaccines in beef cattle (*M* = 3.48; *SD* = 0.79), and disagreed that they would purchase and consume beef administered the mRNA vaccine (*M* = 2.39; *SD* = 1.05). These publics are likely to serve as positive or negative opinion leaders (Hallahan, 2000; Rhodes, 2022; Wu et al., 2019) of mRNA vaccines in beef cattle. The active publics (high issue involvement/relatively high knowledge) had negative attitudes (*M* = 2.21; *SD* = 0.93), neither agreed nor disagreed that there is risk associated with mRNA vaccines in beef cattle (*M* = 2.57; *SD* = 0.75), and agreed that they would purchase and consume beef administered the mRNA vaccine (*M* = 4.03; *SD* = 0.61). Active publics will require support and acknowledgement (Hallahan, 2000) from agriculture communicators.

Synthesis of Findings

The qualitative and quantitative studies provide the livestock industry, specifically the beef industry, insight into stakeholder perceptions surrounding the use of mRNA vaccines in animal agriculture. Across both studies, our findings indicated that both beef producers and beef consumers possessed limited knowledge about the mRNA vaccine technology and the current regulatory status of the vaccine in livestock. In the qualitative study, producer participants indicated their consumers had expressed concerns about the administration of the mRNA vaccine. The conversations held between the producers and their customers in the qualitative study represent the misinformation that has been seen on social media (Frank, 2023). The consumer study further supported these findings based on the results of the knowledge construct.

While some consumers had more knowledge of mRNA vaccines in beef cattle than others, overall, knowledge was noticeably low. The low number of correct responses to some of the knowledge questions in the quantitative study, such as the approval status of the mRNA vaccine in livestock, could suggest that consumers are believing the misinformation that is being spread on social media. Presenting fact-based information to consumers and producers, especially through social media, is needed to increase knowledge of the mRNA vaccine.

Across both studies, there were weak attitudes held by both producers and consumers related to the administration of mRNA vaccines in livestock, but none of the attitudes were inclined to be positive. In the qualitative study, producers' attitudes were weak, being mostly negative or neutral. The participants' attitudes may reflect their lack of knowledge of the mRNA vaccine, with one participant indicating they did not have enough information about the vaccine to form an opinion. Another participant in the qualitative study mentioned that most of the conversations surrounding the mRNA vaccine had been negative, apart from the positive comments made by cattlemen's associations or pharmaceutical companies. Neutral or negative attitudes were also seen by the consumers in the quantitative study. If attitudes regarding the administration of mRNA vaccines to beef cattle continue to lean towards being negative, the application of this novel technology could be limited if approved in the future. Advocating for the benefits of the mRNA vaccine and educating stakeholders of the research being conducted on the vaccine will be essential to forming positive attitudes in consumers and producers.

In the qualitative study, participants mentioned they would be hesitant to implement mRNA vaccines on their operation due to consumer concern. The participants explained how they were worried about losing customers who opposed administering the mRNA vaccine to beef cattle. However, results from the quantitative study indicated that, overall, participants neither

agreed nor disagreed that they would purchase beef from cattle administered the mRNA vaccine. The findings from the quantitative study reveal that consumers may not be as concerned as producers perceive about purchasing beef products that have been administered the mRNA vaccine. However, direct-to-consumer beef producers have a stronger connection to their consumers compared to consumers who purchase beef from a grocery store, where they are not sure where their beef was produced. However, the intent to purchase beef that has been administered a mRNA vaccine could be dependent on consumers' marketing preference. The relationship held between a direct-to-consumer producer and their consumer is much stronger compared to a producer who provides beef to an intermediary and a consumer that purchases beef at a large retail store. If this study were to evaluate specifically consumers who purchase beef from a local producer, their perceptions about the mRNA vaccine could vary from those who solely purchase beef from grocery stores.

Limitations

A limitation for this thesis was that the Food and Drug Administration (FDA) had not approved mRNA vaccines for use in livestock animals at the time of this study, thus limiting both producers' and consumers' familiarity with the vaccine. Furthermore, both studies focused solely on the beef industry, making the findings not generalizable to other livestock sectors such as the sheep and goat industry or the swine industry. The qualitative study that conducted interviews with East Tennessee, direct-to-consumer beef producers have some limitations that should be considered when interpreting the findings. Due to the precise location (East Tennessee), small sample size (n = 7), and qualitative nature of the study, the findings are not generalizable. Another limitation was that data saturation seemed to be met in the qualitative study, but additional data points could have influenced the findings. One limitation of the

quantitative study was the instrument was distributed through an online platform (Qualtrics). The survey questions required a forced response, and fatigue could have impacted the quality of responses. Another limitation of the quantitative study was the respondents were presented with the definition of mRNA vaccines in the middle of the survey. This definition could have influenced their answers to the question presented before and after the definition was provided. Lastly, while it was requested for Qualtrics to implement quotas that matched the U.S. census for demographics, some of the quotas were relaxed. This served as a limitation as it caused some of the sample to be skewed from the U.S. population.

Recommendations

Findings from these studies provide both agriculture practitioners and researchers with preliminary, yet foundational, information related to producers' and consumers' perceptions of the administration of mRNA vaccines in beef cattle if the vaccine was to be approved by the Food and Drug Administration in the future.

For Practice

Across both studies, our findings indicate that there is a general lack of knowledge of the mRNA vaccine technology by both producers and consumers. At this stage of the approval process, focus for communication and outreach efforts needs to be placed on providing factual information to producers and consumers. While this research focused on the beef industry, agriculture practitioners should consider providing educational materials related to mRNA vaccines across different livestock sectors as well.

Based on the findings from the qualitative study with producers, Extension specialist in Tennessee should create outreach programs/campaigns that educate direct-to-consumer, beef producers on the mRNA vaccine technology and the current regulations/policies surrounding the

vaccine. This will enhance producers' knowledge of the mRNA vaccine and better equip them for conversations that are being held with their consumers. Additionally, resources, such as posters/brochures, directed toward consumers with information related to the mRNA vaccine could be created for producers to distribute at farmers markets or their on-farm retail stores. The content of these outreach programs/campaigns and communication resources will need to be updated as the approval status of the mRNA vaccine in livestock evolves. If the mRNA vaccine were to be approved in the future, transparent communication with producers about the benefits of the novel vaccine technology and how to overcome consumer stigma will be essential if the industry wants the implementation of this disease-control technology to be successful.

Findings from the quantitative study revealed that not only is there a gap of knowledge related to the use of mRNA vaccines in beef cattle, but there is also a general lack of knowledge regarding vaccine techniques and protocols that are used by cattle producers currently. It could be beneficial for agriculture practitioners to provide consumers with information related to general livestock vaccines regulation and administration before focusing on mRNA vaccine communication. This does not mean information about mRNA vaccines is unimportant. Rather, understanding general, current vaccination practices in the livestock industry will allow consumers to better comprehend the mRNA vaccine technology. Agriculture communicators should focus on creating information that targets each category of publics in this study. While some publics (aware and active) did possess more knowledge related to the mRNA vaccine compared to others, our findings indicated that knowledge is still considerably low. As stated previously, education of the mRNA vaccine technology will be an important first step to enhance consumer acceptance of the vaccine. With inactive publics being the largest group in this study and possessing the lowest amount of issue involvement and knowledge, agriculture practitioners

should focus on building relationships with this category of publics (Hallahan, 2000) as there is an opportunity to influence their perceptions of the novel technology. It will be important for agriculture practitioners to monitor the behavior of the aware publics, as they often serve as opinion leaders (Hallahan, 2000) and could either promote or demote mRNA vaccines in livestock to consumers.

For Research

The qualitative study was not generalizable due to the focus on a specific location and use of a small sample size; therefore, there are many opportunities for this research to be expanded in the future. The qualitative study could be replicated throughout other areas in Tennessee and the United States to understand regional influences on direct-to-consumer beef producers' perceptions of mRNA vaccines. Additionally, researchers could evaluate different industry stakeholders' opinions of the mRNA vaccine technology, such as large-scale beef producers, meat processors, cattlemen's groups, and veterinarians. These evaluations could use qualitative methods, such as interviews or focus groups; however, quantitative studies would allow researchers to better understand how the variables seen in the Theory of Planned Behavior predict intent to use the mRNA vaccine technology and increase the generalizability of the findings.

The quantitative study provides the animal agriculture industry with foundational data regarding consumers' perceptions of mRNA vaccines; however, there are many opportunities for future research on this topic. Future studies should investigate if consumers' perceptions of mRNA vaccines in livestock are related to their opinions of the COVID-19 mRNA vaccine used in human medicine. In addition, research is needed to further evaluate our findings across the groups of publics. Research should seek to understand why the aware publics (low issue

involvement/relatively high knowledge) disagreed they would purchase beef from cattle that had been administered the mRNA vaccine. Studies could be conducted to understand why the aroused publics (high issue involvement/relatively low knowledge) take interest in the issue, but why that interest has not increased their knowledge of the subject. Using qualitative methods to determine why the active (high issue involvement/relatively high knowledge) and aroused (high issue involvement/relatively low knowledge) publics have negative attitudes about the use of mRNA vaccines of livestock but have positive purchasing intent behaviors could provide researchers with an in-depth understanding of these behaviors. If the mRNA vaccine does become approved for use in animal medicine, this quantitative study could be replicated to determine if consumer perceptions have changed. Additionally, research that examines consumers' perceptions compared to their willingness-to-pay for beef administered the mRNA vaccine could help clarify some of the contradictory variables across the groups of publics. Lastly, message testing would help agriculture communicators determine the best way to relay information about mRNA vaccines in livestock to consumers.

Summary

In recent years, public concerns surrounding the use of the novel mRNA vaccine technology in livestock have emerged on social media platforms (Frank, 2023) despite the vaccine not being approved for use in livestock (Strickland, 2023). This thesis sought to explore the perceptions and behaviors of beef producers and beef consumers related to the use of mRNA vaccines as a method of disease prevention. Interviews were conducted with seven (n = 7), direct-to-consumer beef producers in East Tennessee using the Theory of Planned Behavior (Ajzen, 1991). In addition, a national survey was conducted with 519 (n = 519) beef consumers.

The qualitative study demonstrated that producers' weak attitudes (which could be influenced by low knowledge), perceived negative subjective norms, and lack of perceived behavioral control would likely lead to low behavioral intent to implement the mRNA vaccine on their operations in the future. Findings from the quantitative study indicated that, overall, consumers remained neutral in the areas of issue involvement, attitudes, risk perceptions, and purchasing intent related to mRNA vaccines in beef cattle. In addition, consumers' knowledge of the novel vaccine technology was considerably low. The quantitative study grouped consumers into four categories of publics: active (high issue involvement/relatively high knowledge), aware (low issue involvement/relatively high knowledge), aroused (high issue involvement/relatively low knowledge), and inactive (low issue involvement/relatively low knowledge; Hallahan, 2000). Grouping consumers in these categories can allow agriculture communicators to form strategic communication that targets the characters of each public.

Based on the findings from this study, agriculture practitioners should focus on enhancing knowledge of the mRNA vaccine technology and its current regulatory status to both producers and consumers. Future research should further investigate the perceptions of the mRNA vaccine by producers, consumers, and other stakeholders in the livestock industry. This research will be extremely important if the vaccine was to become approved for use. The agriculture industry has witnessed how the public's negative perceptions toward novel agriculture technologies can limit their application, such as Genetically Modified Organisms (GMOs). In order for mRNA vaccines to become a successful disease-management tool in the livestock industry, agriculture practitioners need to be proactive in communication strategies related to this ground-breaking, vaccine technology.

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APPENDICES

APPENDIX A

Qualitative Study IRB Approval

DOANE UNIVERSITY

Blake Colclasure <blake.colclasure@doane.edu>

IRB Exemption Notice F22 EX03 DC IRB HS

IRB Doane <irb@doane.edu> Tue, Dec 13, 2022 at 2:27 PM
To: Blake Colclasure <blake.colclasure@doane.edu>

TO: Blake Colclasure

FROM: Timothy Frey, IRB Chair

RE: Exemption Notice for "Factors influencing livestock farmers' decision-making regarding modern management practices for zoonotic infectious disease prevention"

DATE: December 13, 2022

This letter is to notify you that the project, *Factors influencing livestock farmers' decision-making regarding modern management practices for zoonotic infectious disease prevention*, has been reviewed and is exempt from IRB review at Doane University. The specific exemption is listed below.

(2) *Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; (ii) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or (iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination.*

This exemption is based upon the assurance that you will:

- Protect the rights and welfare of research participants;
- Participants are able to legally give consent if required
- To the extent allowed by the protocol, select subjects equitability among the potential populations of participants;
- Adhere to all Doane College IRB Policies and Procedures Relating to Human Subjects, as written in accordance with the Code of Federal Regulations (45 CFR 46);
- Maintain copies of all pertinent information related to the research study including, but not limited to, video and audio tapes and other forms of image capture, instruments, copies of written consent agreements, and any other supportive documents in accordance with Doane College IRB Policies and Procedures Relating to Human Subjects.

- Report to the Doane College IRB immediately if any of the following occur:
  - Unanticipated problems
  - Unanticipated deviations from previously approved protocols
  - Any proposed changes from the previously approved research.

If needed you may include on your consent forms contact information for the Doane IRB: e-mail irb@doane.edu, or contact Tim Frey, 402-826-8648.

The exemption code for this project **F22 EX03 DC IRB HS**. You may use this code to indicate to participants that the project has been reviewed by the Doane College institutional review board.

Tim Frey
Chair, Institutional Review Board
Doane University

APPENDIX B

Semi-Structured Interview Guide for Qualitative Study

Moderator reads: Hello [Participant's Name]. Thank you for taking time to provide your insights to our research today. My name is Blake Colclasure and I am a faculty member from the University of Tennessee in the Department of Agricultural Leadership, Education and Communications. This research project is also in partnership with Doane University in Nebraska, my former university of employment. I will be conducting our discussion with you today that will explore your experience and perceptions as a small-scale beef production in Eastern Tennessee. We believe this research will provide important information that can be used to guide program development to support small-scale been production in the region.

We appreciate your interest and willingness to complete this discussion. My role here is to ask questions and to listen. We welcome all opinions and will keep them confidential, so please feel free to say what you think. This session will be recorded so that we are better able to review your comments later. For the sake of clarity, please be sure to speak loudly and clearly so that our recorders can pick up your comments. We will be on a first-name basis during our interview, but in our later reports there will not be any real names or identifying information shared. We will also use pseudonyms in later reports. You may be assured of confidentiality.

If at any time you wish not to answer a question, remove yourself from the interview, or drop out of the study, you may do so. There are no direct risks to you by participating in this research. You will receive a $100 check to thank you for your participation. If you feel that you have not been treated fairly or if your rights as a research participant have been violated, you may contact Doane University's Institutional Review Board at irb@doane.edu or by calling (402) 826-6736. Our session will last between 30 minutes and 60 minutes. Before we begin, I

need to collect your informed consent to participate in this study. If you voluntarily agree to participate, and are over 19 years of age, please state your name and confirm that you agree to participate.

Thank you, let's get started!

Part I. Intro to Farmer / Farm / Icebreaker (rapport building) (5-10 min)

- About Farmer
    - Location (may pre-document if known)
    - Tell me a little a bit about yourself. (will focus on the "farm" later)
    - Farmer characteristics (age / race/ethnicity / gender) and years of farming experience.
    - Education level (any postsecondary formal education)
    - New/beginning operation or has the farm been in the family?
    - Membership in agricultural organization.
        - TN Farm Bureau
        - TN Cattlemen's or Cattlewomen's Association
        - Other

- Farm Characteristics
    - Size / typical number of head of cattle.
    - Type of cattle breed(s)
    - Describe the type of operation (e.g., calf to finish, backgrounder, cow-calf, etc.; feeding system, grass-fed/grass-finished, etc.)
    - Any particular sustainability-based practices that may be unique to your operation
    - General marketing of the product (e.g., farmer's market, online, etc.)
    - Other type of livestock and/or crops

Part II. Resources Used or Training/Workshops to Guide Cattle Production Management (10 minutes)

- When seeking information to guide your cattle/farm management decisions, where do you go or what resources do you use? (start with open-ended; mention below if not initially discussed).
    - Extension programs such as Master Beef Producer Program. Trust-level.
    - Beef Quality Assurance Certification?
    - Tennessee Ag Enhancement Program (TEAP). Provides cost-share dollars for agricultural producers.
    - Any programs associated with your professional memberships. Trust-level.
- Use of any of the following resources to guide farm management decisions.
    - Family members. Trust-level.
    - Other Beef Farmers – how to get this information. Trust-level.
    - United States Department of Agriculture. Trust-level.
    - University of Tennessee (beyond Extension). Trust-level.
    - Local Vet. Trust-level.
    - Other sources of information, including:
        - News/information on Television (examples). Trust-level.
        - News/information on Social Media (Facebook, groups, etc.) Trust-level.
        - News/information on Radio. Trust-level.
        - News/information on other Internet Websites. Trust-level.
        - News/information on YouTube. Trust-level.
        - Other Resources (books, print media like Newspapers).

Part III. Transition to On-the-farm Practices (10 minutes)

Animal Health & Herd Management

- What strategies do you use to **monitor** beef animal health? Signs/symptoms of unhealthy animals.

- Strategies for animal disease or sickness **prevention**.
- Strategies you use if you identified an animal as showing signs for symptoms of being unhealthy (disease, physical ailment)
- What do you think are the **largest issues that small scale beef producers are experiencing** when it comes to the health and safety of their cattle operations? (can have them elaborate on this a bit – mention over-the-counter antibiotics ban, if not initially mentioned.).
- Suggestions for Research/Education/Extension to reduce barriers/challenges.
- What considerations go into selecting the vaccines you use for your herd?
- What do you know about mRNA vaccines used in livestock?
    - "mRNA vaccines use messenger RNA, which occurs naturally in all cells, to teach cells how to make a protein which will trigger an immune response."
    - Approved for swine but not cattle
- If mRNA vaccines were approved for use in cattle in the future, what would inform your decision regarding whether or not to use this type of vaccine?
- What concerns if any, do you have with the use of mRNA vaccines in livestock
    - Consumer acceptance, labeling, policy, etc.

Part IV. Consumer-Facing Practices (10 minutes)

- Based upon your interaction with customers, have you noticed any consumer trends or concerns, for example things that consumers are asking you when they look to purchase beef products.
- How do you specifically market your beef products? (e.g., safety / health terminology like BQA, All Natural, Organic, etc.)
- Use of environmentally sustainable practices / market or promote these to your consumers. Any consumer demand for these types of practices?
- Animal welfare / marketed/promoting. Any consumer demand for certain practices?

Part V. Conclusions (5 minutes)

- Any other thoughts or things that you believe would be good for us to know?
- Provide Summary of Main Discussion Points / Member-Checking

APPENDIX C

Quantitative Study IRB Approval

THE UNIVERSITY OF TENNESSEE KNOXVILLE

August 19, 2024

Taylor Kathryne Ruth
UTIA - UTIA - Ag Ldrship, Educ & Comm

Re: UTK IRB-24-08366-XM
Study Title: American Consumers' Perceptions of mRNA Vaccines used in Livestock

Dear Taylor Kathryne Ruth:

The Human Research Protections Program (HRPP) reviewed your application for the above referenced project and determined that your application is eligible for **exempt** review under 45 CFR 46.101, pursuant to Category 2: Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
Your application has been determined to comply with proper consideration for the rights and welfare of human subjects and the regulatory requirements for the protection of human subjects.

Therefore, this letter constitutes full approval of your application (version 1.0) as submitted, including:
Documents Stamped:

- mRNA_Study_survey version 1.0
- mRNA Consent_Revised version 2.0

that have been dated and stamped IRB approved. You are approved to enroll a maximum of 1000 participants. Approval of this study will be valid from 08/19/2024 - 08/18/2027.

Any revisions in the approved application, consent forms, instruments, recruitment materials, etc., must be submitted to and approved by the IRB prior to implementation. In addition, you are responsible for reporting any unanticipated serious adverse events or other problems involving risks to subjects or others in the manner required by the local IRB policy.

Approval of this study is valid for three years. If a Study Update Form is not submitted in iMedRIS and approved by the IRB prior to 08/18/2027, the study will be automatically closed by the IRB and no further study activity will be permitted until a Study Update Form is received. Please be sure to also submit a Study Closure Request (Form 7) when all research activity, including data analysis, has been completed.

Sincerely,

Institutional Review Board | Office of Research & Engagement
1534 White Avenue Knoxville, TN 37996-1529
865-974-7697 865-974-7400 fax irb.utk.edu

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Flagship Campus of the University of Tennessee System

APPENDIX D

Full Survey Instrument

Consent for Research Participation

Research Study Title: American Consumers' Perceptions of mRNA Vaccines used in Livestock

Researcher(s): Dr. Taylor Ruth, University of Tennessee, Knoxville

I am asking you to be in this research study because you are a U.S. resident. You must be age 18 or older to participate in the study. The information in this consent form is to help you decide if you want to be in this research study. Please take your time reading this form and contact the researcher(s) to ask questions if there is anything you do not understand.

Why is the research being done?

The purpose of the research study is to understand U.S. consumers' perceptions of mRNA vaccines used in livestock.

What will I do in this study?

If you agree to be in this study, you will complete an online survey. The survey includes questions about livestock vaccines and beef preferences/purchasing intent and should take you about 15 minutes to complete. You can skip questions that you do not want to answer.

Can I say "No"?

Being in this study is up to you. You can stop up until you submit the survey. After you submit the survey, we cannot remove your responses because we will not know which responses came from you.

Are there any risks to me?

We don't know of any risks to you from being in the study that are greater than the risks you encounter in everyday life.

Are there any benefits to me?

We do not expect you to benefit from being in this study. Your participation may help us to learn more about consumer perceptions of mRNA vaccine use in livestock. We hope the knowledge gained from this study will benefit others in the future.

What will happen with the information collected for this study?

The survey is anonymous, and no one will be able to link your responses back to you. Your responses to the survey will not be linked to your computer, email address or other electronic identifiers. Information collected for this study will be published and possibly presented at scientific meetings.

Will I be paid for being in this research study?

You will not be paid for being in this study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the researchers, Dr. Taylor Ruth, 865-974-3522. For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact: Institutional Review Board The University of Tennessee, Knoxville Phone: 865-974-7697 Email: utkirb@utk.edu

Statement of Consent

I have read this form, been given the chance to ask questions and have my questions answered. If I have more questions, I have been told who to contact. By selecting "I Agree" below, I am providing my signature by electronic means and agree to be in this study. I can print or save a copy of this consent information for future reference. If I do not want to be in this study, I can select "I Do Not Agree" to exit out of the survey. o o I do not agree to participate

- ◯ I agree to participate
- ◯ I do not agree to participate

Have you purchased and/or consumed beef products (e.g. steak, ground beef, roast, etc.) in the past 6 months?

- ◯ Yes
- ◯ No

What gender do you identify as?

- ○ Male
- ○ Female
- ○ Other
- ○ Prefer not to answer

Which category(ies) best describes your race(s)? (Feel free to select more than one if applicable).

- ☐ White
- ☐ Hispanic, Latino, or Spanish origin
- ☐ Black or African American
- ☐ Asian
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Other Pacific Islander

What state do you currently live in?

What is your current zip code? (i.e., 32607)

What year were you born? (e.g. 1989)

To start the survey, we would like to ask you questions about your thoughts towards vaccines in general.

Please click the arrow to continue.

From the list of vaccines below, which of the following vaccines are you aware of for use in people and/or animals?

Please check all that apply.

- [ ] Inactivated Vaccines
- [ ] Live-Attenuated Vaccines
- [ ] Messenger RNA (mRNA) Vaccines
- [ ] Recombinant Vaccines
- [ ] Toxoid Vaccines
- [ ] Viral Vector Vaccines
- [ ] None of the above

Please indicate how much you agree or disagree with the following statements.

Each statement will describe a different type of vaccine technology.

"I trust the safety of...."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Inactivated Vaccines	○	○	○	○	○
Live-Attenuated Vaccines	○	○	○	○	○
Messenger RNA (mRNA) Vaccines	○	○	○	○	○
Recombinant Vaccines	○	○	○	○	○
Toxoid Vaccines	○	○	○	○	○
Viral Vector Vaccines	○	○	○	○	○

The next set of questions will ask you about the use of messenger RNA vaccines, or **mRNA vaccines**, specifically.

Please click the arrow to continue.

Select the circle between each set of adjectives that best represents your thoughts about the use of mRNA vaccine technology for humans.

The administration of mRNA vaccines in humans is...

Good	○ ○ ○ ○ ○	Bad
Positive	○ ○ ○ ○ ○	Negative
Not beneficial	○ ○ ○ ○ ○	Beneficial
Acceptable	○ ○ ○ ○ ○	Unacceptable
Necessary	○ ○ ○ ○ ○	Unnecessary
Important	○ ○ ○ ○ ○	Unimportant
Not essential	○ ○ ○ ○ ○	Essential
Crucial	○ ○ ○ ○ ○	Trivial

Select the circle between each set of adjectives that best represents your thoughts about the use of mRNA vaccine technology in beef cattle.

The administration of mRNA vaccines in beef cattle is...

Good	○ ○ ○ ○ ○	Bad
Positive	○ ○ ○ ○ ○	Negative
Beneficial	○ ○ ○ ○ ○	Not Beneficial
Unacceptable	○ ○ ○ ○ ○	Acceptable
Necessary	○ ○ ○ ○ ○	Unnecessary
Unimportant	○ ○ ○ ○ ○	Important
Essential	○ ○ ○ ○ ○	Not essential
Crucial	○ ○ ○ ○ ○	Trivial

Select the circle between each set of adjectives that best represents your thoughts about purchasing and consuming beef from cattle administered the mRNA vaccine.

Purchasing and consuming beef from cattle administered a mRNA vaccine is...

Good	○ ○ ○ ○ ○	Bad
Negative	○ ○ ○ ○ ○	Positive
Not Beneficial	○ ○ ○ ○ ○	Beneficial
Acceptable	○ ○ ○ ○ ○	Unacceptable
Necessary	○ ○ ○ ○ ○	Unnecessary
Unimportant	○ ○ ○ ○ ○	Important
Not essential	○ ○ ○ ○ ○	Essential
Crucial	○ ○ ○ ○ ○	Trivial

We are interested in understanding your knowledge about topics related to vaccines in beef cattle.

For the next set of statements, please select "True" for statements that you believe are true. Select "False" for statements that you believe are not true.

If you are unsure or do not know the answer, please select "I Don't Know."

Vaccinations in beef cattle are mainly used for the treatment of disease when the animal becomes ill.

- ◯ True
- ◯ False
- ◯ I don't know.

Beef producers can purchase vaccines without a prescription from a veterinarian.

- ◯ True
- ◯ False
- ◯ I don't know.

Beef producers are not required to have a veterinarian present to administer vaccines to beef cattle.

- ◯ True
- ◯ False
- ◯ I don't know.

The vaccine technologies used on beef cattle are required to be listed on a food product label.

- ◯ True
- ◯ False
- ◯ I don't know.

The vaccine technologies present in beef cattle vaccinations are listed on the vaccine label.

- ◯ True
- ◯ False
- ◯ I don't know.

Vaccines have established withdrawal periods, which is the time that must elapse between the administration of the product and the slaughtering of a food animal.

- ◯ True
- ◯ False
- ◯ I don't know.

The Center for Veterinary Medicine (CVM) tests new animal drugs for safety and effectiveness.

- ◯ True
- ◯ False
- ◯ I don't know.

Currently, there is no federal requirement for beef cattle to receive vaccinations.

- ◯ True
- ◯ False
- ◯ I don't know.

mRNA vaccines have been approved by the USDA and FDA for use in cattle, sheep, goats, and swine in the United States.

- ◯ True
- ◯ False
- ◯ I don't know.

mRNA vaccines are used in beef cattle to help prevent the spread of COVID-19.

- ◯ True
- ◯ False
- ◯ I don't know.

The administration of a mRNA vaccine to beef cattle can alter the genetic makeup of its meat.

- ◯ True
- ◯ False
- ◯ I don't know.

Food products such as steak, ground beef, roast, etc. from beef cattle that have been administered an mRNA vaccine will contain residue of the mRNA vaccine.

- ◯ True
- ◯ False
- ◯ I don't know.

The next set of questions will ask you to share your thoughts and opinions about **mRNA vaccines in beef cattle.**

For the purpose of this survey, please use the following definition for mRNA vaccines:

"A messenger Ribonucleic acid, or mRNA, vaccine contains genetic material (mRNA) that tells the body how to make a protein, which triggers an immune response to create antibodies to fight disease."

Please indicate your level of disagreement or agreement with the following statements regarding purchasing intent and consumption of beef products from cattle administered the mRNA vaccine.

"I would..."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
purchase beef products from cattle administered the mRNA vaccine for myself.	○	○	○	○	○
purchase beef products from cattle administered the mRNA vaccine for my friends and family.	○	○	○	○	○
consume beef products from cattle administered the mRNA vaccine.	○	○	○	○	○
Please select "Agree"	○	○	○	○	○
offer beef products from cattle administered the mRNA vaccine to friends and family.	○	○	○	○	○

Please select the statement below that best represents your perspective regarding the use of mRNA vaccine technology in beef cattle.

"The administration of mRNA vaccines in beef cattle..."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
will negatively impact my health.	○	○	○	○	○
will positively influence my purchasing decisions.	○	○	○	○	○
causes me concern.	○	○	○	○	○
would increase beef availability for myself.	○	○	○	○	○
leads to safer beef products.	○	○	○	○	○
will make beef more affordable.	○	○	○	○	○
would increase food safety in beef.	○	○	○	○	○
will decrease the quality of beef products.	○	○	○	○	○
is a topic of conversation amongst my family and friends.	○	○	○	○	○

Please indicate your level of disagreement or agreement with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I believe that consuming beef products from animals administered the mRNA vaccines could pose a risk to my health.	○	○	○	○	○
I am concerned of beef cattle diseases that could be contagious to me.	○	○	○	○	○
I believe there will be residue of the mRNA vaccine in the products I consume from beef cattle administered the mRNA vaccines.	○	○	○	○	○
I am concerned there are unknown health impacts associated with the consumption of beef products from animals administered the mRNA vaccine.	○	○	○	○	○

Please indicate your level of disagreement or agreement with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I believe that beef cattle's health is at risk when they are administered mRNA vaccines.	○	○	○	○	○
I am skeptical of new vaccine technologies that are created for beef cattle.	○	○	○	○	○
I believe that mRNA vaccines could serve as a useful tool for disease management in beef cattle.	○	○	○	○	○
The use of mRNA vaccines in beef cattle can alter their genetic makeup.	○	○	○	○	○

Please indicate your level of disagreement or agreement with the following statements.

"I trust that..."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Beef producers make vaccination decisions that benefit both their operation and consumers.	○	○	○	○	○
Beef producers adhere to approved vaccination practices.	○	○	○	○	○
Retailers ensure that beef products from beef cattle are safe for purchase and consumption.	○	○	○	○	○
Governmental agencies develop regulations to ensure that the beef products remains safe for consumption.	○	○	○	○	○
Animal pharmaceutical companies produce vaccines that are researched, tested, and proven to be safe.	○	○	○	○	○
Veterinarians are knowledgable about vaccination protocols for beef cattle.	○	○	○	○	○

We would like to gain an understanding about how you approach and deal with situations as they arise throughout life.

When answering the following questions, please try to indicate the degree to which you agree or disagree with the statements as they relate to how you naturally tend to approach situations.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I don't like to have to do a lot of thinking.	○	○	○	○	○
I try to avoid situations that require thinking in depth about something.	○	○	○	○	○
I prefer to do something that challenges my thinking abilities rather than something that requires little thought.	○	○	○	○	○
I prefer complete to simple problems.	○	○	○	○	○
Thinking hard and for a long time about something gives me little satisfaction.	○	○	○	○	○

The next set of questions will ask you about your general beef consumption and purchasing behaviors.

During the past month, how many times did you **purchase raw/frozen beef products** to prepare for your home?

- ◯ More than 5 times a week
- ◯ 4-5 times a week
- ◯ 2-3 times a week
- ◯ Once a week
- ◯ Once every 2 weeks
- ◯ Once a month
- ◯ Other

[ ]

- ◯ None

During the past month, how often have you **consumed** beef products in your home, at restaurants, at fast-food chains, etc.

- ◯ Daily
- ◯ More than 5 times a week
- ◯ 4-5 times a week
- ◯ 2-3 times a week
- ◯ Once a week
- ◯ Once every 2 weeks
- ◯ Once a month
- ◯ None

Who do you primarily purchase beef products for? (Please check all that apply)

- ☐ Self
- ☐ Spouse or domestic partner
- ☐ Child/Children
- ☐ Other

Where do you usually purchase beef products (steaks, hamburgers, ground beef, roasts, etc.) from?

Check all that apply.

- ☐ Supermarket (in-person)
- ☐ Supermarket (online)
- ☐ Restaurants
- ☐ Fast food chains
- ☐ Farmers market
- ☐ Meal subscription service
- ☐ Local beef producer
- ☐ I raise my own beef.
- ☐ Other

Please indicate how much you agree or disagree with the following statements.

"I prefer to purchase beef that is..."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Natural	○	○	○	○	○
Organic	○	○	○	○	○
Grass fed	○	○	○	○	○
Local	○	○	○	○	○
Antibiotic/Hormone free	○	○	○	○	○
Kosher	○	○	○	○	○

To end the survey, please answer the following questions about yourself.

Please indicate how much you agree or disagree with the following statements.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I trust the safety of the COVID-19 vaccine.	○	○	○	○	○
I trust the effectiveness of the COVID-19 vaccine.	○	○	○	○	○

How would you describe the location where you currently live?

- ◯ Urban
- ◯ Suburban
- ◯ Rural

What is your marital status?

- ◯ Single, never married
- ◯ Married, civil union, or domestic partnership
- ◯ Divorced
- ◯ Separated
- ◯ Widowed
- ◯ Other (please specify)

Are you the parent or guardian for any children younger than 18 years old?

- ◯ Yes
- ◯ No

Which of the following best describes your political beliefs or values?

- ◯ Very Liberal
- ◯ Liberal
- ◯ Moderate
- ◯ Conservative
- ◯ Very Conservative

What is your highest level of completed education?

- ◯ Less than 12 years (did not complete high school or GED)
- ◯ High School (or GED)
- ◯ Some college credit, no degree
- ◯ 2-year college degree
- ◯ 4-year college degree
- ◯ Master's degree
- ◯ Professional degree (e.g., JD, MD)
- ◯ Doctoral degree

How would you classify the primary income of the household you are from?

- ◯ Farming household (more than 50% of family income is from the farm)
- ◯ Non-farming household

What is your total household income, before taxes?

- ◯ Less than $25,000
- ◯ $25,000-$49,999
- ◯ $50,000-$99,999
- ◯ $100,000-$124,999
- ◯ $125,000-$149,999
- ◯ $150,000-$174,999
- ◯ $175,000-$199,999
- ◯ $200,000-$224,999
- ◯ $225,000-$249,999
- ◯ $250,000 or more

Please select all of the following social media applications you use at least once a week.

- [ ] Facebook
- [ ] Twitter (X)
- [ ] Instagram
- [ ] Snapchat
- [ ] YouTube
- [ ] Reddit
- [ ] Pinterest
- [ ] TikTok
- [ ] Other

- [ ] I do not use any social media

APPENDIX E

Survey Constructs Analyzed for Quantitative Study

Attitudes:

Purchasing and consuming beef from cattle administered a mRNA vaccine is...

Good	○ ○ ○ ○ ○	Bad
Negative	○ ○ ○ ○ ○	Positive
Not Beneficial	○ ○ ○ ○ ○	Beneficial
Acceptable	○ ○ ○ ○ ○	Unacceptable
Necessary	○ ○ ○ ○ ○	Unnecessary
Unimportant	○ ○ ○ ○ ○	Important
Not essential	○ ○ ○ ○ ○	Essential
Crucial	○ ○ ○ ○ ○	Trivial

Knowledge:

Vaccinations in beef cattle are mainly used for the treatment of disease when the animal becomes ill.

- ◯ True
- ◯ False
- ◯ I don't know.

Beef producers can purchase vaccines without a prescription from a veterinarian.

- ◯ True
- ◯ False
- ◯ I don't know.

Beef producers are not required to have a veterinarian present to administer vaccines to beef cattle.

- ◯ True
- ◯ False
- ◯ I don't know.

The vaccine technologies used on beef cattle are required to be listed on a food product label.

- ◯ True
- ◯ False
- ◯ I don't know.

The vaccine technologies present in beef cattle vaccinations are listed on the vaccine label.

- ◯ True
- ◯ False
- ◯ I don't know.

Vaccines have established withdrawal periods, which is the time that must elapse between the administration of the product and the slaughtering of a food animal.

- ◯ True
- ◯ False
- ◯ I don't know.

The Center for Veterinary Medicine (CVM) tests new animal drugs for safety and effectiveness.

- ◯ True
- ◯ False
- ◯ I don't know.

Currently, there is no federal requirement for beef cattle to receive vaccinations.

- ◯ True
- ◯ False
- ◯ I don't know.

mRNA vaccines have been approved by the USDA and FDA for use in cattle, sheep, goats, and swine in the United States.

- ◯ True
- ◯ False
- ◯ I don't know.

mRNA vaccines are used in beef cattle to help prevent the spread of COVID-19.

- ◯ True
- ◯ False
- ◯ I don't know.

The administration of a mRNA vaccine to beef cattle can alter the genetic makeup of its meat.

- ◯ True
- ◯ False
- ◯ I don't know.

Food products such as steak, ground beef, roast, etc. from beef cattle that have been administered an mRNA vaccine will contain residue of the mRNA vaccine.

- ◯ True
- ◯ False
- ◯ I don't know.

Purchasing Intent:

"I would..."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
purchase beef products from cattle administered the mRNA vaccine for myself.	○	○	○	○	○
purchase beef products from cattle administered the mRNA vaccine for my friends and family.	○	○	○	○	○
consume beef products from cattle administered the mRNA vaccine.	○	○	○	○	○
Please select "Agree"	○	○	○	○	○
offer beef products from cattle administered the mRNA vaccine to friends and family.	○	○	○	○	○

Issue Involvement:

"The administration of mRNA vaccines in beef cattle..."

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
will negatively impact my health.	○	○	○	○	○
will positively influence my purchasing decisions.	○	○	○	○	○
causes me concern.	○	○	○	○	○
would increase beef availability for myself.	○	○	○	○	○
leads to safer beef products.	○	○	○	○	○
will make beef more affordable.	○	○	○	○	○
would increase food safety in beef.	○	○	○	○	○
will decrease the quality of beef products.	○	○	○	○	○

Risk Perceptions:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I believe that consuming beef products from animals administered the mRNA vaccines could pose a risk to my health.	○	○	○	○	○
I am concerned of beef cattle diseases that could be contagious to me.	○	○	○	○	○
I believe there will be residue of the mRNA vaccine in the products I consume from beef cattle administered the mRNA vaccines.	○	○	○	○	○
I am concerned there are unknown health impacts associated with the consumption of beef products from animals administered the mRNA vaccine.	○	○	○	○	○

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I believe that beef cattle's health is at risk when they are administered mRNA vaccines.	○	○	○	○	○
I am skeptical of new vaccine technologies that are created for beef cattle.	○	○	○	○	○
I believe that mRNA vaccines could serve as a useful tool for disease management in beef cattle.	○	○	○	○	○
The use of mRNA vaccines in beef cattle can alter their genetic makeup.	○	○	○	○	○

VITA

Bailey Watson grew up on a part-time cow/calf operation in Max Meadows, Virginia, where she was exposed to agriculture from a young age. She earned her Bachelor of Science degree in Animal and Poultry Science from Virginia Polytechnic Institute and State University in May 2023. Bailey will graduate with a Master's degree in Agricultural Communications at the University of Tennessee – Knoxville in May 2025. Her research focuses on science communication within the livestock industry, specifically examining consumer and producer perceptions of the use of mRNA vaccines in beef cattle. In addition to her thesis research, Bailey serves as a graduate teaching assistant in the Department of Agricultural Leadership, Education and Communications, where she assists in course instruction and supports student learning. Upon completing her master's degree, she plans to pursue a career in the agriculture industry, utilizing her expertise in animal science and agricultural communications to advocate for agriculture, particularly the beef industry.