Reflecting Back on Animal Disease Preparedness and Response in the West from 2009-2019 and Looking Forward to the Next Challenge

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Abstract

Animal disease preparedness involves an array of activities to enhance the ability to prevent or mitigate the effects of high consequence diseases. Outbreaks of highly pathogenic avian influenza and virulent Newcastle disease in the last decade tested animal disease preparedness investments in the West and highlighted areas where planning and research are still needed. This paper reflects on those eradication efforts and lessons learned from 2009-2019, as well as future challenges and opportunities pertaining to animal health in Western states, specifically resource limitations, public perceptions, and business continuity plans.

Introduction

Reflecting on the last decade, livestock industries and animal health response agencies have faced an increase in global disease threats and have responded to multiple disease challenges. Animal health policy has advanced in the wake of lessons learned domestically and abroad to prepare the US for future, and possibly greater, challenges in the form of transboundary animal diseases (TAD) —also referred to as foreign animal diseases (FAD). TADs are diseases currently circulating elsewhere in the world and have the potential to severely impact the health and productivity of US livestock populations, the livelihoods of farmers and ranchers, and the export market share of US meat and livestock products. Among others, TADs include diseases such as foot-and-mouth disease (FMD), classical swine fever (CSF), African swine fever (ASF), virulent Newcastle disease (VND), and highly pathogenic avian influenza (HPAI). The 2018-2019 ASF outbreak in China, as an example, has made headlines and rocked global pork markets in 2018 and 2019 due to the high death loss and the difficulty of killing the virus in the environment, even after the removal of infected hogs. To limit such losses, the US must be prepared to respond rapidly in the event of a domestic introduction of TAD.

Being prepared requires an investment of time and resources and is essential for preventing and reducing the effects of TAD outbreaks. The term "preparedness" encompasses an array of activities including reviewing standard response processes (e.g. sampling and lab processing); stockpiling critical materials and equipment; supporting new research and development; prevention/mitigation and response planning; and practicing response through tabletop or functional exercises. Some preparedness investments are broadly applicable across TADs. For example, commercial swine depopulation technologies developed in preparation for FMD would also be deployable in the event of ASF or CSF. Other preparedness investments are more specific, such as stockpiling vaccines in the North American Vaccine Bank for threats such as FMD and HPAI.

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This ongoing need for investment in animal health preparedness was recognized when mandatory spending in the 2018 Agricultural Improvement Act was set aside specifically for enhanced animal disease preparedness and response capacity, including enhancement of the National Animal Health Laboratory Network, and the development of a US animal disease vaccine bank. This funding has created an opportunity to enhance the resilience of US livestock industries to TADs, which has never been more critical given the threat of TAD introduction and the historic size of US livestock inventories. This paper reflects on eradication efforts and lessons learned from 2009-2019, with specific emphasis on Western states, as well as future challenges and opportunities pertaining to animal health. The goal is to provide perspective on the importance of animal disease preparedness and why investments in preparedness are a necessity rather than an option.

Background: Animal Disease Challenges in Western States 2009-2019

Between 2005 and 2012, 8,345 HPAI outbreaks occurred globally in 65 countries. Those outbreaks were largely spread through live bird markets after introductions of the disease in small-scale poultry operations from wild bird contact. While relatively rare worldwide, over 700 human infections from HPAI H5N1 occurred from 2003-2018—none of those cases occurred in the US (CDC, 2019). In response to outbreaks worldwide, the US government invested in enhanced stockpiles of response equipment and supplies, trained responders, and created response plans. Poultry growers adopted enhanced biosecurity to prevent the introduction of HPAI and worked closely with animal health response agencies to develop business continuity plans to maintain movements of low-risk products. If the US was ready to respond to any TAD, it was HPAI.

From 2013-2018, a new wave of HPAI in international domestic poultry occurred resulting in 7,011 outbreaks in 68 countries—including the US (OIE, 2018). The US experienced HPAI in 232 flocks (211 commercial flocks and 21 backyard flocks) in 2014 and 2015, a turkey flock in 2016, and 2 Tennessee chicken flocks in 2017. The 2014-2015 HPAI outbreaks challenged animal disease preparedness/mitigation due to the large number of outbreaks occurring over a 7-month period, large number of states with infected flocks (15), and the diverse types of flocks affected. Western states with domestic poultry infections included California (2 flocks), Idaho (1 flock), Montana (1 flock), Oregon (2 flocks), and Washington (5 flocks). The outbreak resulted in the depopulation of almost 50 million birds and cost between $879 million and $1 billion in total economic cost to producers (Johansson *et al*., 2016). Despite being the largest and most expensive TAD outbreak in US history, the disease was successfully eradicated with no re-introductions on restocked farms. Such success was a testament to the importance of preparedness and the hard work of industry and animal health authorities. Johansson *et al*. (2016) estimated that, without the timely federal response, the damages to poultry industries could have doubled or tripled, meaning the benefits of timely response outweighed the cost of that response. However, many lessons were learned during those HPAI outbreaks as previously developed response plans were tested in very difficult conditions. It was evident that preparedness and mitigation must be constant and progress as industries evolve in complexity. A 2016 report outlined priority preparedness activities prior to the next big outbreak.[3]

Unfortunately, the threat to Western poultry populations was not over. In 2018-2019, California was challenged again with a second poultry health event—virulent Newcastle disease (VND). The VND outbreak was very different from HPAI in terms of geographic spread and the types of farms most impacted. VND resulted in 455[4] infected flocks concentrated in only 3 contiguous counties, with limited detections in 3 other California counties, 1 flock in Utah and 1 flock in Arizona. VND was also different from HPAI in the method of disease introduction and spread. HPAI in 2014-2015 along the Western US was most likely caused by wild bird introductions moving along the Pacific migratory flyway. The 2018-2019 VND outbreaks were characterized by lateral spread among backyard flocks, at least some of which comingled at live bird markets and exhibition events. Of the 1.7 million domestic poultry and fowl depopulations/deaths associated with HPAI, LPAI and VND from 2009 to 2019 in Western States, 69% of poultry depopulations/deaths were associated with the 2018-2019 VND outbreak. The VND outbreak was also much longer, lasting over a year, but the trade consequences were limited due to many of the infected flocks being non-commercial. Although the largest TAD challenges to Western states in the last decade have been associated with poultry disease, preparedness activities have and must encompass other threats as well.

The Potential Value of Preparedness in Foot and Mouth Disease Response

Preparedness is a continuous process. To see this in action, consider preparedness for FMD. The introduction of FMD to the United States can be considered one of the most dangerous TAD threats (Breeze, 2004). Since 1929, the US has not experienced an FMD outbreak and is currently considered FMD free without vaccination (Ward *et al*., 2009). All cloven-hoofed animals are susceptible to infection. In Western states, the susceptible animal population includes the high value dairy industry and cattle feeding industry. In addition, a large part of the nation's small ruminant herd is in Western states and FMD can occur, with limited clinical signs, in sheep

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[3] Those recommendations are outlined in the "2016 HPAI Preparedness and Response Plan" available online at: https://www.aphis.usda.gov/animal_health/downloads/animal_diseases/ai/hpai-preparedness-and-response-plan-2015.pdf

[4] This number will not reflect any new detections after November 2019. Report available online at: (https://www.aphis.usda.gov/animal_health/downloads/animal_diseases/ai/epi-analyses-vnd-in-backyard-birds-in-california-july.pdf)

and goat populations. This creates a potential for "silent" disease spread among the small ruminant population in the same region that contains large numbers of susceptible cattle and, to a lesser extent, swine populations.

If an FMD outbreak were to occur, immediate depopulation of infected livestock, quarantines and movement restrictions ("stamping-out") are an effective response to eradicate the disease in a timely manner (McReynolds and Sanderson, 2014). Depending on the extent of disease spread before the disease is first detected, stamping-out may result in large production losses. Simulations of an FMD outbreak occurring in a 40,000+ feedlot located in Kansas showed greater than 1.2 million out of the 2 million cloven-hoofed animals in the surrounding area would be culled (Pendell *et al*., 2007). Removal of such significant numbers of animals not only depletes available supplies from an industry, but previous studies have identified depopulation incurs significant costs as the method is laborious and requires significant logistical planning (DeOtte and DeOtte, 2010; McReynolds and Sanderson, 2014). Rapid detection has the potential to reduce the overall duration of outbreaks, head removed, and overall economic impact. Carpenter *et al*. (2011) found that a single day of delay in detection in the first case of disease, from 21 days to 22 days post infection, could result in 2,000 more cattle depopulated and $565 million in losses for every hour of delay.

From an economic perspective, the largest potential financial losses associated with FMD outbreaks are typically caused by the loss of international trade (Ekboir, 1999; Paarlberg *et al*., 2002). For a net exporting country, the loss of exports could result in greater losses than production losses from the disease itself (Junker *et al*., 2008). Ekboir (1999) found an FMD outbreak beginning in California could lead to losses between $8.5 million and $13.5 billion with a substantial share of those losses being credited to US meat export restrictions. Industries may be unable to adjust supply levels quickly to offset the reduced international demand, and consequently, domestic prices may decline for products like pork and beef in net exporting countries. Longer outbreaks result in longer trade embargoes and mitigation strategies that reduce the duration of outbreak typically have the greatest impact on reducing the overall economic burden of disease (Paarlberg *et al*. 2008). Hagerman *et al*. (2012) examined the effectiveness of an animal traceability system in FMD surveillance during a simulated outbreak in the Texas panhandle. The study found that a reduction in the delay to tracing from 10 days to 2 days reduced the cost of the outbreak by $180 million and reduced the number of cattle placed under movement restrictions by 15,000 head.

In addition to the cost of disease response, value of depopulated animals, and trade losses, secondary losses in service industries and declines in consumer confidence are also viable concerns during an FMD outbreak. A significant portion of demand for feed grains in the US is linked to the livestock industry's need to feed their animals. When herd numbers decrease, demand for feed grains also declines, resulting in lower feed grain prices (Hagerman *et al*., 2009). The goal of an FMD response is to stop the spread of the virus. However, the strategy implemented could depend on the economic consequences of the strategy.

Vaccination for Disease Mitigation: An Opportunity and a Challenge

Some TADs have viable, commercially available vaccines to aid in eradication (e.g. FMD, CSF and HPAI), whereas others do not (e.g. ASF). Livestock producers might wonder, if a viable vaccine for a TAD is available, why the vaccine is not used in the US to prevent disease introduction. For some diseases, the answer is partially biologic. Like the annual influenza shot for humans, an FMD vaccine has to match the circulating strain to offer much protection. With 60+ serotypes of the FMD virus circulating in the world, it is difficult to match the circulating strain. Consider HPAI vaccines, which could be administered to a day-old chick but would require approximately 21 days to be fully effective, and then withdrawal periods must be observed before harvest[5]. This is unlikely to be feasible for certain sectors of commercial poultry production, like the high value broiler industry. A larger part of the answer is related to global meat and animal production trade market access. Any country that uses systematic vaccination would potentially face additional sanitary restrictions on their products, even when a disease outbreak is not ongoing.

So, if vaccination is only used after a TAD outbreak has begun—where the vaccine can be matched to the exact virus strain and production types allow appropriate withdrawal times—the timing and implementation of the vaccine strategy becomes critical. Herein lies the motivation for a US vaccine bank, in addition to the existing North American Vaccine Bank shared with Canada and Mexico. An effective emergency vaccine campaign, in conjunction with stamping-out, would require rapid vaccine availability, rapid vaccine administration, and tracking of all vaccinated animals. The vaccine bank, which stocks the "starter stockpile" of vaccine, would provide the first wave of inoculations, followed by steady supplies after the manufacturer increases production to meet the need of the outbreak.

The US vaccine bank is tasked with prioritizing FMD vaccine stockpiles first. New vaccines have been developed for FMD that allow testing to differentiate infected from recovered animals (called DIVA vaccines). These vaccines open up a new list of possibilities for the management of vaccinated animals after an outbreak has ended. Prior to DIVA vaccines, vaccinate-to-kill[6] strategies

[5] Based on USDA-APHIS HPAI vaccination guidelines available online at: https://www.aphis.usda.gov/publications/animal_health/2015/fs-hpai-vaccine-use.pdf

[6] A strategy in which vaccinated animals serve as a limiter to disease spread, but are depopulated afterward rather than live out their productive life or enter the food supply.

were often utilized under the justification that early removal of vaccinated animals may speed the removal of trade embargoes. When vaccinate-to-live[7] strategies are implemented, the burden of proving disease freedom may be more costly due to additional surveillance. Geale *et al*. (2013) called for a review of World Animal Health Organization (OIE) guidelines on recommended timelines to lift trade embargoes when a country's FMD response includes a DIVA vaccine. In the Western US, a new DIVA vaccination strategy could protect high value dairy or breeding stock, without requiring subsequent depopulation of vaccinates.

Preparedness challenges and opportunities for the next decade

The next decade will see changes among consumers and animal industries. In addition to existing animal health threats, emerging threats require flexibility in response planning. Three issues in preparedness will be discussed in more detail: resource limitations, public perceptions, and business continuity.

Limitations in Resources and Increasing Industry Complexity

The poultry and swine industries have changed in structure over the last 20 years. Today, most inventories are concentrated in intensively managed indoor facilities that contract with a small number of processing companies. In the beef sector feedlots have, for some time, been concentrated in a limited number of states. This concentration of livestock in the different meat sectors stresses resources in the event of an outbreak. In Iowa, multiple egg-laying hen facilities with more than a million birds became infected with HPAI during the 2015-2016 HPAI outbreak, which posed challenges for depopulation, disposal and cleaning and disinfection. Johnson *et al*. (2016) describes some of the resource limitations in the HPAI outbreak, such as water for foam depopulation on turkey farms and large equipment rental availability for cleaning and disinfection. In another example, DeOtte and DeOtte (2010) examine the resources needed to respond to FMD in a 70,000 head feedlot. They estimated it would take 4.5 days to depopulate the feedlot and another 11 days to dispose of carcasses. Carcass burial for the depopulated cattle was estimated to require 90 acres of land and cost $1.8 million (DeOtte and DeOtte, 2010).

At the other end of the spectrum are responses focused on smallholder populations, like the backyard poultry flocks involved in the 2018-2019 VND outbreak in California. Almost 90% of livestock farms in the US are considered "small". From surveillance and movement restrictions, to cleaning and disinfection, preparing for an outbreak on a small farm is very different to preparing for an outbreak on a large, commercial farm. Resource limitations will continue to be an issue for animal health response in US animal industries. Future research will need to consider the current and future trends in herd/flock housing, management and size under limited resources. Research areas may include questions around strategic stockpiling, targeted response strategies, and the returns on investments in research and development.

Managing Public Perceptions at Home and Abroad

Public perception of disease occurrence and response strategy selection must also be considered, particularly in the rapidly changing digital world. Preparedness involves more than just preparing responders or livestock industries. It is also preparing to respond when the public demands answers and reassurances about the safety of US food supplies. Today, this is complicated by consumers' desire for information on management and humane handling of livestock. Domestic avoidance of meat after an FMD outbreak could lead to severe economic losses for the US if consumer confidence in the livestock and meat industry declined and substitutions for meat were found (Paarlberg *et al*. 2008). In the 2001 UK FMD outbreak, media images of pyres of burning carcasses caused a negative reaction by UK consumers (Thompson *et al*., 2003). Taiwan experienced the loss of 65,000 jobs in service industries during a 1997 FMD outbreak (Yang *et al*., 1999) while the 2001 United Kingdom FMD outbreak left a loss of $4.2 to $4.9 billion in tourism revenue (Thompson *et al*., 2002). Given the large population centers and the value of tourism from outdoor activities in Western states, advanced planning to manage the public's risk perceptions in a disease outbreak may be a necessary part of disease preparedness. Future research could explore consumer perceptions of diseases, response strategies, and what is needed to regain consumer confidence after disease eradication.

Globally, great strides have been made to use risk-based disease information when setting the magnitude and length of trade embargoes for sanitary reasons. "Regionalization" refers to the recognition of certain parts of a country as disease free and consequently exempt from sanitary trade embargoes. In practice, regionalization has limited undue damages from animal diseases. In the 2014-2015 US HPAI outbreak, bilateral trade restrictions were placed at the national and regional level (Seitzinger and Paarlberg, 2016). The broiler industry in the Southeastern states particularly benefited from regionalized trade embargoes. Economists can offer industry, policy makers, and animal health agency officials input on the most impactful preparedness activities to limit negative public perceptions by domestic consumers as well as trade partners.

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[7] A strategy in which animals vaccinated with a DIVA vaccine, that are non-infected as evidenced by the accompanying diagnostics, live out their productive life and can enter the food supply chain.

Business Continuity

In addition to preparing for response on infected farms, preparedness also encompasses planning for the continued movement of low-risk products from non-infected premises that are within movement control areas. Proactive risk assessments have resulted in Secure Food Supply (SFS) plans to assist in business continuity in the event of an outbreak. SFS plans were implemented during poultry disease outbreaks in the last decade, and plans for pork and beef production are in development. One example of how research and planning have merged is the Secure Milk Supply and the development of bulk milk tank testing for FMD. California is a leading milk producer in the US and the state has a large import-export business from ocean ports, increasing the risk of accidental introduction of FMD to the US. Bulk milk tank testing has the potential to swiftly detect FMD, while limiting high-risk contacts of cattle during an active disease response. Future research could include measuring the impact of business continuity plans on farm-level or regional resilience.

A Way Forward: There Is No Silver Bullet

The realities of animal disease preparedness, response, and recovery are ever changing. Nothing stays the same—viruses mutate, industries grow and evolve, policies change. The risk of disease exposure and infection are increasing every day. This risk comes from increasing global travel, movements of live animals and meat products, the survivability of some viruses in the environment, wildlife interactions (particularly the continued expansion of feral hog populations), and the continued growth of small scale or backyard livestock production. People are also more connected than ever, and information from both official and unofficial sources is just a tap on the smart phone away.

Within a few years, California experienced two poultry disease outbreaks—HPAI in 2014-2015 and VND in 2018-2019. The outbreaks were vastly different, and as a result, the eradication response had to be different to be effective. Western states face unique challenges in their livestock sectors, environmental and legal restrictions, and geographic landscapes. Furthermore, as animal health authorities prepare for the disease threats already known in the world, the possibility of emerging diseases cannot be ignored. ASF was a threat with a much lower probability of occurring on US soil not long ago. Now, the US plays a waiting game with ASF. In the last decade, the US has experienced a great deal of forward progress in preparedness. Scientific advancements may bring new tools to bear in animal disease response. After all, there is no way to predict what the next challenge will be. Only through flexibility, collaboration, and refusing to become compliant can the US best position itself to overcome the next big outbreak. This overview of lessons learned from the last decade and challenges for the future is in no way exhaustive, but rather is meant to serve as a starting point for the next wave of discussions on preparedness activities.

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