General Sessions

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Livestock Disease Surveillance: Meeting Future Needs

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Abstract

As a result of the expansion of global trade and travel, livestock disease surveillance has rapidly evolved from a stance of looking at and within our borders for threats to looking more intensively across the globe for threats. The projected intensification of livestock production in developing nations will likely broaden the scale, diversity, and consequences of disease outbreaks. Numerous challenges face the development and implementation of effective global and domestic livestock disease surveillance. Our profession is well-positioned to advocate, develop, and utilize novel technologies, novel strategies, and novel sources of human resources to meet these challenges.

Résumé

En raison de l'expansion du commerce et des voyages internationaux, la surveillance des maladies du bétail a rapidement franchi nos frontières: on surveille dorénavant plus intensivement toute menace venant de l'étranger. L'intensification prévue de l'élevage du bétail dans les nations en développement augmentera d'autant plus l'étendue, la diversité et les conséquences des épidémies de maladies. De nombreux défis attendent l'élaboration et la mise en oeuvre d'une surveillance mondiale et nationale des maladies du bétail. Toutefois, notre profession est bien placée pour recommander, découvrir et utiliser des technologies, des stratégies et des ressources humaines nouvelles qui nous permettront de relever ces défis.

Introduction

Livestock disease surveillance is defined as the continuous, systematic collection, analysis, and interpretation of specific data regarding adverse livestock health events. These data are subsequently used to direct planning, implementation, and evaluation of control or preventive strategies. In addition, timely dissemination of accurate information to essential audiences is a requisite component of modern surveillance programs. Together, these response actions focus on identification of the etiology, measurement of the scale of the event, epidemiologic investigations to identify the source(s) and means of spread, and specific control measures to attenuate or eradicate the threat. Response activities are typically triggered when targeted adverse health events occur at a rate that exceeds a predetermined threshold.[10] For endemic diseases, that threshold rate of occurrence may be determined by the individual or combined expertise or authority of the livestock producer, veterinarian, allied animal health specialists, and regulatory personnel. In contrast, the threshold for foreign animal diseases and high-priority zoonotic diseases is often defined by the detection of a single case, and for those countries with well-developed animal health infrastructure, the authority to act is clearly ensconced in the regulatory realm. Therefore, the threshold for triggering action in a surveillance program is determined by the nature and consequences of the disease in question.

One or more methodologies for surveillance may be employed in a given program. Etiologic surveillance systems are designed to detect the presence of specific causes of disease (e.g. infectious agents). Diagnosis-based surveillance systems track the spatial and temporal occurrence of clinical diagnoses, whereas syndromic surveillance programs – a subtype of diagnosis-based surveillance – track groups of clinical signs that typically precede or are associated with a clinical diagnosis or detection of an etiologic agent.[4] Livestock disease surveillance programs that include one or multiple types of surveillance methodology have been and will continue to be a pivotal component of disease control and eradication programs in North America and elsewhere.[6,9,10] Currently active animal and human disease surveillance programs, ranging in scope from municipal to global, that utilize these methodologies have recently been reviewed.[10]

There has been a recent and profound evolution in the geographic, political, climatic, human, animal, pathogen, and production system factors that affect the type, scope, and spatial and temporal distribution of live-

stock diseases worldwide.[4,8-11,14] As our capacity to detect and define animal disease events rapidly and necessarily expands, and as emerging and re-emerging diseases broaden the number of diseases for which surveillance is deemed prudent, our capacity to link disease detection to logical, ultimately constructive actions must also expand. This expansion, however, must occur in the face of a serious, and at the very least an intermediate-term, limitation in the availability of veterinary professionals in rural practice, food supply medicine, and public health practice in many countries, a crisis that experts view as the most pressing need facing our profession today.[11,12] In this review, the major challenges that lie ahead for livestock disease surveillance will be summarized, and potential opportunities to expand our global and domestic surveillance capacity will be discussed.

Challenges

Population dynamics and demand for animal products

Our capacity to detect disease in animals and humans is not only driven by advances in science, and therefore in our detection capabilities, but in the forces that influence the rates and types of disease events. For livestock diseases, a vital shaping force is the expanding human population and the concurrent expansion of both demand for and production of animal protein. Currently estimated at 6.5 billion people, the world's population has nearly doubled during the lifetime of many currently in our profession (~60 years) and is projected to nearly double again by 2100.[5] The developing world is expected to comprise the largest proportion of world population growth during this period.[10] Importantly, the projected demand in the developing world for high-quality protein in the form of meat and milk is expected to nearly double between 1997 and 2025.[16] Food exports from developed countries will likely expand to compete for this increased demand for animal protein in developing nations; however, expansion and intensification of animal production systems within developing countries is projected to occur as well.[16]

This demand-driven expansion in animal production in developing countries will bring forth novel interactions between livestock, people, and the environment. In turn, these changes are predicted to exacerbate the risk of emerging, zoonotic, livestock, food-borne, and trans-boundary diseases in developing countries. This risk can be assumed, in the era of globalized trade and rapid travel, to potentially involve nations far removed geographically from the point of origin.[8,10,16] Paradoxically, developing countries tend to possess more rudimentary veterinary and food safety infrastructure, thereby limiting the capacity of these nations to detect and respond to these diverse disease threats. Diagnostic laboratory capacity and epidemiological expertise are in particularly short supply in many developing nations.[10] However, in many diagnostic laboratories in the developing world, notable advances have recently been made in detection capabilities, accessibility of services, and the basic technical skills of affiliated personnel.

Hunger, conflict, and political stability

Both the acreage suitable for agriculture and the political climate conducive to long-term, constructive agricultural reform are irregularly distributed across the developing world.[3] It stands to reason, therefore, that an increased production capacity for animal protein will likely not be symmetrically distributed across the developing world. Although vastly improved in scope in recent history, world hunger and malnutrition continue to hamper the human condition even in nations such as India, which is currently experiencing robust economic expansion.[3] Few of us would question the contention that veterinarians play a vital role in addressing this timeless humanitarian problem, but history strongly suggests that hunger cannot be remedied by ethical justification alone. Limitations in food supply have historically served as effective, if not always overt, sources of political instability for developing nations: the food riots in Egypt, Bangladesh, and other developing countries, triggered by increases in grain prices in 2007 and 2008, are vivid recent reminders. Hunger is a potent driving force for insurrection and intra- and international conflict; in fact, in current failed or failing states, extremists are using food as a lure for recruits for various causes.[3]

Intentional disruption of food supplies or food-related economies is a well-worn tool in the arena of human conflict. Deliberate infliction of casualty within livestock populations and the resultant deficits in animal protein and fiber can be used to exacerbate food shortages, incite economic hardship and civil unrest, and cause resettlement of human and animal populations. The recent emergence of sustained, asymmetric warfare, coupled with increased international access to the necessary resources and expertise, has revealed the renewed potential for extremist groups to consider agroterrorism and bioterrorism as a means to achieve political or social agendas. Surveillance, therefore, can be viewed as a vital tool for national defense and for ensuring political stability abroad. For policy makers with a limited understanding of disease, animal husbandry, or food production, the benefits of livestock disease surveillance may need to be framed by its proponents as an essential component of food security – with its attendant enhancement of national security and stability - before necessary political support can be garnered.[10]

Resource allocation

Recent events, such as the anthrax attacks in the US and other countries during this decade, the spread

of avian influenza among poultry and waterfowl in Asia, Africa, and Europe, the introduction of West Nile virus into North America, and the H1N1 influenza pandemic in humans have generated heightened public awareness of the need for surveillance systems with the capability of early warning against novel disease threats. Also recently, the occurrence of large-scale foodborne disease outbreaks has enhanced the public awareness of the need for a modernized food safety surveillance system that meets the unique demands of 1) more intensive production settings and a highly centralized processing system for domestic meat and milk production, and 2) a burgeoning volume and diversity of imported food products. Despite heightened public awareness, what remains undetermined at present is the presence of sufficient political and consumer will to pay higher food prices, or to allocate tax dollars, to cover the costs of increased surveillance.

An abundance of surveillance programs for human and/or animal diseases have been made active in the past 20 years.[9,10] Because surveillance systems are developed to address specific issues and needs, each serves a particular purpose, and the integration and transfer of data among these programs can be suboptimal. In times of limited fiscal resources, the programs' diversities, redundancies, and real or perceived lack of cohesiveness can become easy targets for criticism – and loss of funding support. If a surveillance program is pathogen-specific, and the pathogen is not detected, the justification for further investment in that system can be called into question.[10] Provision of concrete proof of disease prevention through surveillance can be challenging for foreign animal diseases and endemic diseases of low prevalence or rare occurrence. Further, the adequacy or inadequacy of a particular level of surveillance is a difficult metric to obtain, not only because of the complex epidemiology of many diseases, but because surveillance is a form of risk management. As such, resources that support surveillance are prone to diversion to the imminent crisis, rather than the sustained threat. In other words, attention and money flow to the crisis at hand at the potential expense of the crisis that looms.[10]

Disparate incentives for surveillance

The rationale for expenditures on surveillance for the global good might be called into question by producers or even by nations, as the short-term penalties in trade that result from identifying priority diseases might outweigh the more nebulous long-term purpose of serving the global good.[10] This disparity in short- versus long-term benefits and national versus international goals fuels the potential incentive for a nation to delay or avoid reporting a priority disease, or to erroneously consider the disease containable within its own borders. Further, the actions that are linked to disease detection can be problematic to implement, particularly in developing countries. Disease control practices that involve culling or quarantine may prove logistically, culturally, and / or politically untenable; vaccines may be difficult to produce, market, store, or distribute; compensation programs may be limited or lacking altogether; and restrictions on market access may be financially unbearable for livestock producers.[13,16] Taken together, these issues may create serious disincentives for producers to participate in livestock disease surveillance programs, thereby undermining the efficacy of such endeavors.[8] Even within developed countries with more advanced surveillance systems, there is considerable potential detriment to erroneous or unconfirmed detection and reporting of certain diseases. Consider, for example, the 2001 rumor of foot and mouth disease (FMD) in Kansas, which had dramatic and immediate adverse consequences on agribusinesses heavily invested in the beef industry.[10]

Opportunities

In light of these highly complex and diverse challenges facing animal agriculture as a whole, what opportunities arise for effective, sustainable livestock disease surveillance? Because the challenges facing disease surveillance span from local issues to those that face the global community, measures to meet these challenges must address a similarly broad range of needs.

In 2005, the Committee on Assessing the Nation's Framework for Addressing Animal Diseases, sponsored by the National Research Council, published a comprehensive review of the national framework for detection, diagnosis, and prevention of animal diseases.[9] Central to this committee's recommendations was the need to engender public support for enhanced veterinary capacity in the fields of epidemiology, food supply medicine, public health, pathology, microbiology, infectious disease research, and laboratory animal medicine. Also cited was the need for greater collaboration between human and veterinary medicine in zoonotic and food-borne disease research, disease surveillance, and diagnostic laboratory activities. The committee also recommended the greater utilization of predictive, risk-based tools and models to develop disease detection, control, and prevention strategies. Veterinary educators were charged with the tasks of increasing the number of veterinarians in relevant public and private disciplines and development of a national animal health education strategy that includes professionals, para-professionals, and caretakers involved in animal health management and husbandry. Those involved in daily care of livestock serve as early detectors of aberrations in the rate and nature of endemic diseases – would they not also serve as the early warning system for novel diseases? The

committee concluded that the laypersons on the front lines of animal disease detection – herdsmen, pen riders, hospital crew members, etc. – are not adequately trained to deal with the broad scope of animal disease issues, including foreign animal diseases and zoonoses.[9] Clearly, the proposed resolutions for US animal health issues are parallel in purpose, if not in scale, to those that could address more global issues.

Development of a more effective, interconnected, and comprehensive global livestock disease surveillance system would require mitigation of numerous disincentives to producers and nations. Reliability and validity of the system would remain as important incentives for support from producers, consumers, and nations. In an era of nearly instantaneous transfer of data via hand-held devices, rapid confirmation of outbreaks, preservation of data confidentiality, and well-organized and transparent disease investigation protocols are requisite components of a sustainable livestock disease surveillance program. Clearly, producer and industry support for such programs would likely suffer if markets were subjected to repeated false alarm reports (false-positive cases).

In developing countries, disease surveillance and control efforts must be linked to improvement of the socioeconomic status of shareholders. Because many high-priority, trans-boundary livestock diseases are endemic in the developing world, a reward system for participation might engender greater public support, such as progressive increments in access to markets in response to sustained risk reduction practices.[8,13] International cooperation in the further development of sound, global animal health infrastructure could result in expansion of validation and certification programs for a given nation's surveillance and control programs. Subsequently, in the event of detection of a high priority, trans-boundary disease, trade restrictions could be enacted on a more geographically relevant basis, enabling continuation of trade for unaffected areas and more rapid restoration of business practices in affected areas.[8,10]

Livestock disease surveillance systems need to be designed to survey, or sample, relevant animal populations. A comprehensive global surveillance system for livestock diseases may require integration of wildlife diseases, human diseases, and environmental components to enhance its effectiveness. Systems that provide abattoir-based data are useful; however, it could be argued that the sample population is composed of animals of a narrow age range that are fit for slaughter, a population that would be less likely to include diseased individuals. As demonstrated in the 2001 FMD outbreak in the United Kingdom (UK), surveillance systems must be attuned to animals as they traverse a given nation's production system – consider the role of auction markets and animal movement in the spread of that disease.[14] Further, for each disease of concern, the system must incorporate all relevant livestock species and diverse production units into the surveyed population. Again, consider the role of sheep and small livestock holdings in the 2001 UK FMD outbreak.[14] To that end, surveillance systems based in auction markets or other collection and distribution points allow for surveillance of multiple species of live animals from multiple points of origin.[15] Systems should be designed to include the use of mass-screening technology with high input and output capacity or adaptation of conventional testing practices at critical control points in livestock transport and distribution networks.[2] Although highly controversial, a national animal identification program, coupled with premise identification, would facilitate analysis of the spatial and temporal data necessary to achieve timely control of a high-priority disease outbreak.

In an era of limited fiscal resources and competing priorities for revision of other components of the nation's infrastructure, livestock disease surveillance systems must be scalable to limit costs. Hierarchical (scalable) surveillance utilizes a scale of intensity of sampling or testing to fit the level of perceived risk.[2] Baseline surveillance can be altered during a time of threat to more directed and purposeful surveillance of high-risk groups. In such systems, both material and human resources are utilized at a rate that mirrors the threat level, thereby limiting expenditures relative to more constant, high-level surveillance systems. Obviously, an integral component to the success of hierarchical systems is a baseline surveillance framework that is adequate to detect changes in threat levels.

Another opportunity for enhancing the effectiveness of both national and global disease surveillance systems lies in augmentation of the ranks of well-trained veterinarians and allied animal health paraprofessionals and laypersons.[10] Relative to recruitment, mentoring, and retention of veterinarians in fields relevant to livestock health, professional organizations – including the American Association of Bovine Practitioners – have acted independently and in concert with other interested groups to address the deficit of this vital human resource. Until a sufficient veterinary workforce is secured in these areas, the number of veterinarians capable of intervening in a modest-to large-scale disease outbreak could be considered to be quite limited. Consider, for example, the 2002-2003 outbreak of Newcastle disease in the southwestern US and the strain imported by that outbreak on regulatory veterinary manpower. If more effective livestock disease control and eradication efforts are desired in the coming years, and if livestock disease surveillance is a critical component of those efforts, should our profession also recruit and train assistants as paraprofessionals to assist in surveillance?

Many experienced men and women serving non-professional roles in animal production systems are

effectively serving as paraprofessionals in skill level and knowledge, if not in title. In developing countries, paraprofessionals are delegated to numerous disease control and eradication tasks – sample collection, vaccination, and surveillance, to name a few[1,7] – while veterinarians serve as trainers and directors of this workforce, and as analysts of the data that these people collect. With formal but basic training in disease surveillance and sample acquisition, this workforce possesses high potential to aid veterinarians in multiple types of surveillance strategies. Such a workforce can be deployed at what is typically a lower cost than using a numerically equal force of veterinarians. Consider, for example, how a trained pool of such individuals could be incrementally utilized in a hierarchical surveillance program. Consider also the value to a national food security strategy of a front-lines corps of livestock workers, animal scientists, and other individuals with daily access to animals, trained in detection of high-priority diseases. As our profession works to expand the ranks of food supply veterinarians, perhaps we should also consider ways to augment the numbers of those who will likely prove invaluable to us in times of need.

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