Disaster Medicine

Veterinary expertise in biosecurity and biological risk assessment

James G. W. Wenzel, DVM, PhD, DACT, DACVPM, and Kenneth E. Nusbaum, DVM, PhD, DACVM

Emerging global conditions have resulted in an increased role for veterinary medicine in the protection of the nation's health, food supply, and economy. Biosecurity is the relatively new term currently applied to a very old concept: preventing the spread of disease. Controlling the spread of strictly animal diseases obviously falls within the purview of veterinary medicine, but veterinarians also play a role in public health by way of zoonotic diseases and other human-animal interactions. Federally accredited veterinarians, in particular, are responsible for preventing the movement of diseased livestock and animal products[1,2] and must certify their competence in specific tasks toward that end to become so accredited. These tasks include, among others, recognition of foreign animal diseases, development of cleaning and disinfection plans, and development of disease control strategies.[3]

Methods of risk assessment, or hazard analysis, vary widely depending on the particular risk. In particular, biological risk assessment may be considered to be the identification, analysis, and characterization of disease threats.[4-6] Depending on the particular agent, this may include evaluation of routes of exposure and infectious dose and consideration of the consequences of disease on individuals and populations. The eventual risk assessment may be quantitative, ordinal, or qualitative, according to the nature of the analysis.

Biosecurity practices are necessarily based on risk assessments, whether formal or informal, such that the use of resources is balanced against the threat. On the 1 hand, insufficient biosecurity may result in more widespread disease. On the other hand, excessively restrictive protocols and expenditure of resources in the presence of minimal risk may lead to unnecessary stress, inefficient use of time, and depletion of limited resources.[a]

The veterinary profession is a source of unique knowledge and skills essential to national biosecurity and biological risk assessment. Although most veterinarians possess such expertise, many do not recognize they possess it or do not realize how their expertise may be applied in the areas of preparedness and response. Recognizing that there are many aspects of biosecurity and risk assessment that cannot be discussed in great detail here, the present article attempts to provide awareness-level information about various elements of biosecurity and risk assessment and provide some new perspectives on these old concepts.

From the Departments of Clinical Sciences (Wenzel) and Pathobiology (Nusbaum), College of Veterinary Medicine, Auburn University, Auburn, AL 36849.
Address correspondence to Dr. Wenzel.

General Biosecurity and Risk Assessment

Preventing or reducing the spread of microbial disease before its presence is recognized is the key characteristic of general biosecurity.[1] Cleaning and disinfecting; barriers of various sorts; and restricting the movements of people, animals, and tools are elements common to most types of biosecurity.

Health professionals, including veterinarians, practice at least some of the elements of general biosecurity on a daily basis. Hand washing, for instance, falls under the heading of cleaning and disinfecting and has been a vital part of general biosecurity since 1847, when I. P. Semmelweis, of the Allgemeines Krankenhaus, the largest maternity hospital in the world at the time, insisted that physicians wash their hands between the autopsy room and obstetrics ward.[7] This simple edict measurably reduced the incidence of puerperal infection, even before the etiology of the syndrome, or indeed even the germ theory of disease, was understood. The story is also a memorable reminder of the arrogance of ignorance.

Routine cleaning and disinfection of clothing and equipment represents the most common method of preventing the iatrogenic dissemination of disease-causing organisms. Veterinarians, particularly veterinarians who work with livestock and other large animals, generally are aware that complete removal of organic debris is necessary for effective microbicidal action of most disinfectants. But this may not be common knowledge among physicians, who often do not deal with such gross contamination.

Barriers are an integral part of biosecurity because they can restrict the movement of microbes and the animals and humans that harbor them. Simple barriers such as outerwear (eg, laboratory coats and coveralls), gloves, and footwear worn during day-to-day activities are part of general biosecurity. They protect the wearer and, if properly cleaned or discarded, prevent transfer of organisms. Complex barrier systems are used to isolate animals with infectious diseases or to exclude pathogens from the animals housed within (eg, specific-pathogen–free production units). These barrier systems typically consist of walls, windows, doors, filters, and screens or curtains. Establishing protocols for entering and exiting such facilities is

important, and although most veterinary curricula do not contain specific training for entering and exiting such facilities, most veterinary students have sufficient experience managing cases in large and small animal isolation facilities that the concepts of containment, if not exclusion, of disease are addressed.[8] Production facilities are increasingly expected to provide barriers between domestic species (ie, poultry and swine) and wildlife or feral populations. On an even larger scale, veterinarians recognize the value of various geographic and political barriers in the reduction of disease transmission. Oceans, mountains, and man-made borders reduce some forms of migration, although seemingly less so in our increasingly globalized society. Whether confining or excluding, health professionals should recognize the importance of various types of barriers to general biosecurity.

When animals or people are being moved, principles of general biosecurity suggest that it is best to move from less contaminated areas or less resistant populations toward areas with greater contamination or more resistant populations. The importance of avoiding cross-contamination increases with the size and susceptibility of the population so exposed. The swine and poultry industries have developed production systems to include protocols for the movement of personnel, feed, and supplies in keeping with these principles. The use of systematic interruptions to movement, such as quarantining or isolating imported animals and purchased additions, increases the opportunity to detect recently acquired and incubating diseases, although this may be somewhat agent-specific. Similarly, veterinary inspection for signs of disease serves as an element of general biosecurity.

General biosecurity typically does not include identification of specific disease-causing agents because general biosecurity is, by its nature, directed at nonspecific threats. Assessing the risk of transmission of or exposure to pathogens whose presence may not yet be recognized and evaluating the potential consequences thereof remain the mainstay of general biosecurity practices.

Industry-Specific Biosecurity and Risk Assessment

A reasonably good definition of biosecurity as it relates to veterinary medicine is management practices that protect resident animals from the introduction of infectious agents harmful to animal health.[9] While relatively simple in concept, when applied to agricultural production, this encompasses a wide variety of considerations and preventive measures (**Appendix**). The USDA has provided information on common, preharvest agricultural biosecurity practices.[10] Additional considerations for specific agricultural industries might include preventing animal contact with contiguous premises; minimizing the risks associated with shared or moving water sources; and reporting of any unusual animals, people, vehicles, or activities.[11,12]

Most national production associations provide extensive, purpose-specific biosecurity information. Concerns for the cattle industry, for instance, include management of purchased additions (including semen and embryos),[13] potential routes of transmission,[14] and source and documentation of feed supplies.[15] Mastitis control is an important aspect of biosecurity that is relatively unique to the dairy industry.[16] Sources of information on biosecurity for equine facilities note the importance of veterinary examination and testing of new arrivals[17] and within-farm control of disease transmission, including segregation by age or other logical grouping.[18] Similar industry-specific suggestions are available for poultry,[19,20] sheep,[21,22] and swine.[23,24]

Veterinarians recognize that a safe supply of food animal products is the result of a continuum of biosecurity from conception and feeding of food-producing animals to human consumption of the resultant products. However, postharvest food-processing industries have many unique biosecurity concerns. Indeed, food safety has become a virtual industry unto itself, with veterinarians on the forefront of food animal product processing and handling. Although food supply industries tend to concentrate products (eg, milk), which affords the opportunity for revolutionary public health interventions (eg, pasteurization), these practices also result in vulnerabilities that must be guarded against, such as accidental or intentional adulteration of large amounts of product.

Risk assessment in animal agriculture and food production includes many practices common to other industries, although some elements are specific to the animal species or type of production. The potential for introduction of disease-causing organisms into animals or food products exists anywhere in the process, but an assessment of the consequences of contamination suggests that the risk is greatest at points of concentration, such as feedlots and food-processing facilities. Certain microbes commonly exist in most milk and meat products, but if refrigeration and food hygiene practices are effective, then the number of organisms is expected to be small, and risk of disease is low. Industry-specific resources for risk assessment at the farm level are available for beef cattle, dairy cattle,[10] horses,[25,26] poultry,[10,19,27] sheep,[26] and swine.[27]

Agent-Specific Biosecurity and Risk Assessment

Biosecurity practices directed at individual agents or groups of agents range from routine to paroxysmal, depending on agent-specific risk assessments. For example, the specific pathogens that cause mastitis in dairy cows are relatively ubiquitous and commonly exist in numbers sufficient to cause infection. Because of this and because of the consequences of mastitis, the threat posed by these organisms is considered to outweigh the costs associated with routine control measures, such as teat dipping. In contrast, although the consequences of foreign animal diseases are severe, because of the low incidence of such diseases, few measures except veterinary surveillance are taken within the nation's borders to control them.

Principles of agent-specific disease control or exclusion biosecurity measures are well illustrated by practices directed at preventing infection with *Mycobacterium avium* subsp *paratuberculosis*[28] and bovine viral diarrhea virus.[29,30] Bovine viral diarrhea virus has

drawn international attention to the degree that the European Commission funds a Web site dedicated to the exchange of information on the subject.[30] Examples of equine diseases requiring rather different, agent-specific biosecurity measures are strangles, caused by *Streptococcus equi*,[31] and equine infectious anemia, which is subject to regulatory control.[32,33] With these diseases, as with many others, agent-specific tests and vaccines are important tools for agent-specific biosecurity.

Testing during quarantine remains a valuable means of agent-specific biosecurity. In particular, this is one of the mainstays of the brucellosis eradication program. Quarantine and testing of purchased additions for endemic diseases such as paratuberculosis and bovine viral diarrhea are important parts of farm-level biosecurity programs. Similarly, quarantine and testing of imports and exports aids in the control of international movement of specific diseases and reduces the probability of introduction of foreign animal diseases.

Event-Specific Biosecurity and Risk Assessment

Specific events might require special biosecurity measures, such as gatherings for competition (eg, state fairs and horse shows) and various disasters resulting in mass destruction or mass casualties (eg, natural disasters and toxic chemical spills). The discovery of certain agents (eg, foot-and-mouth disease virus) in unexpected places may also necessitate event-specific measures. The hallmark of event-specific biosecurity is an increase or improvement in biosecurity measures as a result of a usually abrupt change in risk assessment.

Disease threats are greater at fairs and shows in part because of the commingling of large numbers of animals under various forms of stress. Agents of particular concern are those that can be transmitted through aerosols, vectors, or casual contact, but the possibility that a large gathering of animals might be a target for intentional dissemination of disease organisms should not be discounted. Actions taken to minimize the risk of disease spread might include, for instance, appropriate agent-specific testing and pre-event veterinary inspection.

Biosecurity measures applicable to large-scale disasters depend, of course, on the nature of the disaster and its venue, but they also depend on the species involved, whether domestic, feral, or wild. If dangerous biological, chemical, or other agents are involved, protective zones may be needed to restrict movement into and out of the area, along with barriers (eg, personal protective equipment) and cleaning and disinfecting equipment. If animals are involved, veterinary expertise will be required, but knowledge and skills necessary for providing emergency responses will also be required. Interaction before the onset of any disaster with traditional emergency responders (eg, law enforcement, emergency medical services, and fire and hazardous materials personnel) can better prepare all involved.

Identification of a disease-causing agent will, under certain circumstances, itself become an event requiring specific biosecurity measures. The death of a few farm animals from anthrax is a relatively regular occurrence on a few farms each year in the United States. However, identification of anthrax spores in an unusual or unexpected location may be an event of national concern, resulting in an extensive biosecurity response. Similarly, the discovery of foot-and-mouth disease in a country historically free from the disease would result in a massive biosecurity effort. One can appreciate the need for veterinary expertise in each of these examples.

Other Initiatives

Many governmental, academic, industrial, and private organizations are urging livestock owners and producers to increase their awareness of biosecurity, particularly as it relates to public health.[34] From the veterinary perspective, the USDA is most often the lead federal organization for biosecurity and risk assessment. Accredited veterinarians act on behalf of APHIS, and changes are planned for the accreditation system to increase knowledge and preparedness among accredited veterinarians. In conjunction with this, a national stockpile of emergency veterinary pharmaceuticals, outbreak models, countermeasures, and related items is also being developed.[1]

Under the National Response Plan, and as a result of a memorandum of understanding with the USDA and a statement of understanding with the American Red Cross, AVMA-organized Veterinary Medical Assistance Teams are prepared to respond to animal health emergencies.[35,36] These mobile teams consist of veterinarians, veterinary technicians, epidemiologists, and others and have broad capabilities in disaster response, including biosecurity.

Also in conjunction with the AVMA, the USDA is coordinating the development of a National Animal Health Emergency Response Corps to provide additional personnel in the event of large disease outbreaks. Veterinarians and technicians who are interested in this effort may contact the National Center for Animal Health Emergency Management.[37] Other organizations are developing animal response teams at the state and county levels.[38,39]

An important university-based initiative for the sharing of biosecurity information and expertise is the Academic Network for Foreign Animal and Zoonotic Disease.[40] The Extension Disaster Education Network references extensive efforts in agricultural biosecurity, especially as they relate to disaster mitigation.[41] Other university-based efforts have been directed at enhancement of biosecurity through research[42] and development of instructional materials.[43] The US Department of Homeland Security oversees the Center for Domestic Preparedness, which is developing an agricultural emergency responder training curriculum in conjunction with the USDA.[44] Veterinarians are both the innovators and the primary audience for most of these initiatives.

a. Rushing M, Center for Domestic Preparedness, McClellan, Ala: Personal communication, 2006.

Appendix

Selected aspects of biosecurity for agricultural production units.[9]

- Develop a plan for each farm unit
  - Make practical improvements
  - Increase the biosecurity level
- Enhance perimeter security
  - Erect fences or barriers and gates with signs
  - Provide a separate, controlled access point for visitors
- Establish a visitor approval process
  - Provide a separate public parking area
  - Screen visitors for risk factors (eg, recent foreign travel or animal contact)
  - Maintain dedicated clothing, footwear, and footbaths for visitors
- Improve biosecurity practices of farm personnel
  - Maintain dedicated clothes and boots for all personnel
  - Maintain dedicated boot baths
  - Wash all vehicles that have entered other farms
  - Restrict entry of foreign food products
- Control animal movement
  - Isolate purchased additions for ≥ 3 weeks
  - Obtain replacement animals only from herds with equivalent or better disease status
  - Ensure that vehicles are cleaned prior to transporting animals onto the farm
  - Exclude dogs, cats, and wildlife from feed storage and feeding areas
- Ensure safety of feed and water
  - Eliminate mammalian-derived protein sources
  - Document sources of all protein supplements
  - Document *Salmonella* and coliform status of feeds that may be contaminated
  - Clean water troughs often
- Control vehicle movement
  - Allow only necessary vehicles beyond the public parking area
  - Clean the tires of vehicles that must enter
  - Provide for loading and unloading at the public area
- Enhance manure management
  - Use separate tractor buckets for feed and manure
  - Clean boots and tires before entering animal or feed areas
  - Apply manure only to crops and fields that will not be harvested or grazed for at least 1 year
- Protect human health (especially children and elderly or immunocompromised individuals)
  - Request that animals not be touched (by signs and instructions)
  - Provide hand-washing stations
  - Provide protective footwear and clothing

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