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Causes and Consequences of Emerging and Exotic Diseases of Animals: Role of the Veterinarian

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Causes and Consequences of Emerging and Exotic Diseases of Animals: Role of the Veterinarian

Abstract
Emerging and exotic animal diseases present a growing threat to human and animal health and jeopardize food security. Increases in human and animal populations, with accompanying environmental degradation and globalized trade and travel, enhance opportunities for transfer of pathogens within and between species. The resulting diseases pose enormous challenges now and in the future.

Disciplines
Veterinary Infectious Diseases | Veterinary Microbiology and Immunobiology | Veterinary Preventive Medicine, Epidemiology, and Public Health

Comments
Emerging and exotic animal diseases present a growing threat to human and animal health and jeopardize food security. Increases in human and animal populations, with accompanying environmental degradation and globalized trade and travel, enhance opportunities for transfer of pathogens within and between species. The resulting diseases pose enormous challenges now and in the future.

In most of the world, increased demand for animal protein has resulted in intensified commercial food animal production and/or expanded “backyard” production. Both present unique challenges for disease emergence and control. Emerging zoonotic diseases (those that may be passed from animals to humans) of both food and companion animals are a major threat to public health.

It is inevitable that the world will continue to experience disease outbreaks in the coming decades. Veterinarians play a key role in preventing, detecting, and controlling emerging diseases. The veterinarian’s oath embodies these responsibilities. No matter what career path a veterinarian chooses, it will involve some responsibility for the protection of animal health and welfare, the relief of animal suffering, the conservation of livestock resources and the environment, the protection of public health, and the advancement of medical knowledge.
This chapter will briefly explore the impact of emerging diseases on animal health, public health, and food security. The causes of their emergence and the role of the veterinary profession in preventing, detecting, and controlling these diseases will also be discussed.

Perhaps the best way to understand the impact and importance of emerging diseases is to consider examples from the distant and recent past.

Plague

In the 14th century, plague (Yersinia pestis) was carried from outbreaks in India and China to Italy by merchants returning home. It quickly spread to the rest of Europe. Over one third of the European population died during the ensuing “Black Death” epidemic. The decline in the population was a factor in the fall of the feudal system and the emergence of the industrial revolution. At the time, no one understood where the Black Death came from or how it could be acquired. There was mass panic as some people fled from the cities to the country, others shut themselves into closed communities, and still others thought the cure lay in drinking and merriment, and went from tavern to tavern. The scientific understanding of this disease’s mechanisms, its routes of transmission, and its animal reservoirs has evolved. Scientists now know that more than 200 species of mammals can be infected with Y. pestis, rodents are the reservoir hosts, and fleas can transmit the plague bacillus from rodents to humans. They also realize that humans or other mammals that develop the pneumonic form of the disease can spread the bacterium in exhaled air. This knowledge allows public health professionals to monitor and prevent the transmission of this disease, thus avoiding further devastating, large-scale outbreaks.

Rinderpest

Rinderpest is an acute, highly contagious, viral disease of cattle, domesticated buffalo, and some species of wildlife. It is not a zoonotic disease, yet its introduction into Africa in the 19th century caused starvation and resulted in massive human fatalities. In 1889, cattle shipped from India carried the rinderpest virus to Africa, causing an epidemic that established the virus on the continent. Initially, approximately 90 percent of the cattle in sub-Saharan Africa died as well as many sheep and goats. Wild buffalo, giraffe, and wildebeest populations were decimated. The loss of draft animals, domestic livestock, and wildlife resulted in mass starvation, killing a third of the human population in Ethiopia and two-thirds of the Maasai people of Tanzania. The reduced number of grazing animals allowed thickets to form in grasslands. These thickets served as breeding grounds for tsetse flies, the vector for trypanosomes, resulting in an outbreak of trypanosomiasis (African sleeping sickness) in humans. This rinderpest epidemic is considered by some to have been the most catastrophic natural disaster ever to affect Africa. The Global Rinderpest Eradication Program is a large-scale international collaboration involving vaccination, local and international trade restrictions, and surveillance. This effort may be one of veterinary medicine’s greatest achievements and rinderpest may soon become only the second disease (after smallpox) to be globally eradicated.
West Nile Virus

In 1999, the New York City area of the United States experienced an outbreak of encephalitis in humans of unknown etiology. At the same time, increased deaths were observed in a variety of bird species. Dr. Tracy McNamara, a veterinarian at the Bronx Zoo, hypothesized a link between the disease in birds and humans, and submitted samples from dead zoo birds to the USDA National Veterinary Services Laboratories (NVSL). NVSL, the U.S. Centers for Disease Control and Prevention (CDC), and the University of California, Irvine identified the virus as West Nile, which had never previously occurred in the Western Hemisphere. This virus progressed across North America in the next few years. It is now endemic in North, Central and South America and there is no feasible way to eradicate it. West Nile (WNV) virus infects wild birds, which are the primary reservoir hosts. It is mainly transmitted by mosquitoes, although it can spread between some birds and reptiles by direct contact. Although most humans are infected asymptomatically or develop flu-like symptoms, WNV can cause encephalitis, meningitis, or a paralytic syndrome in less than one percent of infected people. This virus can cause fatal encephalitis in horses and occasionally in other mammals. It also affects alligators, causing severe outbreaks among farmed animals, and it can kill some species of birds. The veterinary vaccine industry, working in cooperation with the USDA Center for Veterinary Biologics, quickly developed an effective vaccine to prevent the disease in horses. WNV vaccine is now considered one of the core equine vaccines in the U.S. and in WNV endemic areas of Canada. The vaccine has also been used off label to protect some endangered birds, such as California condors.

Rift Valley Fever

Rift Valley fever (RVF) is a zoonotic, mosquito–borne viral disease which affects ruminants. Sheep, cattle, and goats may be severely affected and serve as the primary host and amplifiers of the virus. Dogs are highly susceptible to infection and cats can be infected as well. In all affected species, a very high rate of abortion and death in neonates is observed. RVF is endemic in sub-Saharan Africa. Epidemics occur after heavy rainfalls when infected mosquito eggs hatch near large numbers of susceptible animals. RVF first appeared outside Africa in 2000, when outbreaks were reported in Saudi Arabia and Yemen. The virus can also produce mild to severe disease in humans. Between November 2006 and February 2007, RVF caused more than 200 human deaths in Kenya. Control efforts included restricting the movement or slaughter of animals, vaccination of livestock, insect vector control, and public education. RVF could spread to countries outside of Africa via an infected
mosquito, animal, or human, and could become established in a new region following a pattern similar to that of the spread of WNV throughout the Americas.

**Influenza (H5 and H1)**

Influenza viruses are highly prone to mutation and transfer between species. Expanding human and animal populations provide greater opportunities for influenza viruses to mutate and emerge in new species. In 1997, a highly virulent H5N1 influenza virus emerged in domestic waterfowl and poultry in Asia and has been sporadically transmitted to people. Novel influenza viruses also have recently emerged to cause severe disease in dogs (H3N8) and cats (H5N1/H1N1) for apparently the first time. In 2009, a novel H1N1 virus with genetic elements from swine, human, and avian influenza viruses emerged and caused a worldwide pandemic in humans.

**Nipah Virus in Malaysia**

In 1998, a never-before-observed virus emerged in the Malaysian pig population, causing severe respiratory and neurologic signs. The virus spread to swine caretakers resulting in more than 265 cases and over 105 deaths in Malaysia and Singapore. A novel paramyxovirus (Nipah virus) was isolated from a human patient. Both the U.S. CDC and the Australian Animal Health Laboratory sent teams of veterinarians and other specialists to Malaysia within days of isolation of the virus. Working closely with the Malaysian government and scientists, these teams developed diagnostic tests and control strategies (including the culling of more than one million pigs), that resulted in eradication of the virus from the swine population. Between 2001 and 2009, there were no new cases of Nipah virus infection in Malaysia. Scientists have discovered that the virus is carried by healthy fruit bats. The virus is still present in fruit bats in Southeast Asia. Human cases of Nipah virus encephalitis have been reported repeatedly since 2000 in Bangladesh, in some cases due to infection from fruit or fruit juices contaminated by fruit bat saliva or urine. Subsequent human-to-human transmission has also occurred.

**Infectious Salmon Anemia in Chile**

In the late 1990s, salmon farming was established and rapidly expanded into a major industry in Chile. The infectious salmon anemia (ISA) virus, an orthomyxovirus, was first reported in Chile in June 2007 and quickly spread throughout the industry. The outbreak reduced the number of operations in business, reduced the overall harvest, and had serious social and economic consequences. The Chilean government is now working to restructure the industry and strengthen regulatory programs, with the goal of improving environmental and sanitary conditions. The ISA virus also spread to the wild salmon population.

**One World, One Health, One Medicine**

In addition to causing illness and deaths among animals, many emerging diseases threaten human health either because they are zoonotic or because they threaten the food supply. Since 1980, over 75 percent of new emerging human infectious diseases have been vector-borne or zoonotic. In addition, over 60 percent of the 1,461 infectious diseases found in humans are caused by multi-host pathogens that are recognized for their ability to move across species lines.

Today, there is a growing understanding that human health, animal health, and the environment are inextrically linked. Organizations such as the World Organization for Animal Health (OIE) and the World Health Organization (WHO) are working to improve human and animal health by collaborating to address critical global needs. The One Health Initiative www.onehealthinitiative.com was launched in 2008 by the American Veterinary Medical Association and the American Medical Association. The goal of the initiative is to enhance cooperation and collaboration between physicians, veterinarians, and other health professionals.

Veterinarians are on the front line for the detection, prevention and treatment of animal diseases, many of which are zoonotic. Veterinarians not only work to keep animals healthy and treat disease, but conduct research to develop improved vaccines, diagnostics, and therapeutics, and serve as public health professionals. Clients and the public expect veterinarians, no matter what their job responsibilities, to be knowledgeable about emerging and exotic diseases.

**Impacts of Emerging and Exotic Diseases of Animals on Trade: Role of the OIE**

The international organization responsible for tracking diseases in animals worldwide is the World Organization for Animal Health. It was formed in 1924 as the Office International des Epizooties (OIE), in response to an outbreak of rinderpest in Europe. Although the name of this organization has changed, it kept its previous acronym. The OIE is comprised of more than 170 member countries and territories. Its most important function is to inform governments of the occurrence and course of epizootics that could endanger animal or human health. The OIE maintains a list of the most important animal diseases and distributes information about the presence or absence of these diseases in each country. The OIE also publishes the Terrestrial Animal Health Code and the Aquatic Animal Health Code. These “Codes” describe the health measures to be used by the veterinary services, or other authorities of importing and exporting countries, to ensure the safe importation of animals and animal products. The Codes are the primary references for international trade: Countries that are members of the World Trade Organization (WTO) use these documents to meet their obligations under the WTO Agreement on the Application of Sanitary and Phytosanitary
Factors Leading to Disease Emergence and Reemergence

Diseases may emerge and reemerge around the world for a number of interconnected reasons. Factors involved in these outbreaks include:

- Increasing human population
- Increasing numbers of food producing animals
- Human and domestic animal encroachment into wildlife habitat and resulting exposure to wild animals
- Environmental degradation
- Climate change
- Interspecies transfer of pathogens and
- Globalization of travel and trade

While there is not universal agreement on the importance of each of these factors, veterinarians should be familiar with the issues involved.

Increasing Human Population

In the 1940s, Norman Borlaug, who is considered the father of the Green Revolution, conducted research in Mexico to develop new disease-resistant, high-yield varieties of wheat. At that time, the world population was under 2.5 billion people. The development of new crop varieties, mechanized agriculture, and the increased use of fertilizers and irrigation, dramatically increased crop yields and the areas where crops could be successfully grown. These were major factors in the success of the Green Revolution. Dr. Borlaug received the Nobel Peace Prize in 1970 for his work in reducing world hunger. Later, he established the World Food Prize to recognize those who have made the most significant contributions to improving the quality, quantity, and availability of food.

The Green Revolution prevented famine in countries like India and China and changed the face of agriculture forever. However, Dr. Borlaug warned in the 1970s that if the human population continued to expand, the relief from hunger and the prevention of famine afforded by the Green Revolution would only be temporary. According to the United Nations Department of Economic and Social Affairs Population Division, in 2010 the world population will be 6.908 billion. In 2009, 49% of the population lived in cities. By 2050, 70% of the population is projected to live in cities.

Crowded urban environments, especially those without adequate infrastructure, can enhance disease epidemics such as influenza.

Source: United Nations Department of Economic and Social Affairs Division

Measures (the SPS Agreement). More information, as well as the list of diseases reportable to the OIE, can be found at www.oie.int
Increased Food Animal Production

The animal production industry has responded to the increased need and demand for protein by amplifying animal production. Since the early 1960s, animal production has increased dramatically. According to FAO, global cattle production jumped from almost 173 million head slaughtered in 1961 to almost 287 million head slaughtered in 2007; and poultry meat production grew from 7 billion head in 1961 to 54 billion in 2007.

In industrialized countries, it is not unusual to see a poultry laying facility with 150,000 birds per house and a dozen houses at one site, or 50,000 cattle on a feedlot. Large swine and poultry production facilities typically have good biosecurity and practice all-in, all-out management, resulting in better infectious disease control. However, if a disease agent enters one of these facilities, it can spread rapidly within the unit with devastating consequences. A large number of animals on one site can provide extensive opportunities for the infectious agent to replicate and perhaps mutate into a more virulent form.

Large modern food animal operations produce high-quality meat, milk, and eggs efficiently and at reduced cost. These operations help to meet the increasing world demand for inexpensive, high-quality protein. Today, almost half of the global population is urbanized and this is expected to increase. At the same time, increasing pressure is being placed on animal production to ensure it is carried out in an environmentally acceptable way that is mindful of animal welfare. Veterinarians and organized veterinary medicine must play a major role in finding a balance between the needs for efficient food production, conservation of the environment, and animal welfare. The OIE has recently expanded its mission to include developing international standards for animal welfare.
Increased Backyard Animal Production

People in developing countries have also responded to the increased need and desire for animal protein. Both rural and urban dwellers are raising poultry, pigs, or small ruminants in their backyards, or even inside their homes, in order to increase animal protein consumption. This type of production allows the reuse of household waste and crop by-products as feed, and has minimal need for transportation. While backyard animal production provides much-needed protein and income for many of the world’s poor, the close interaction between animals and people can facilitate the spread of zoonotic diseases. These small scale producers often lack knowledge of biosecurity and access to veterinary care, including diagnostic testing and vaccines. In particular, diseases such as H5N1 influenza in poultry and brucellosis in small ruminants present significant zoonotic disease challenges for backyard production in many regions of the world.

Intensive Aquaculture

As overfishing depletes the world’s natural marine and fresh water fisheries, the role of aquaculture is becoming more important. Aquaculture is the fastest growing sector of animal protein production and now accounts for 47-50 percent of the world’s aquatic animal food supply. Production rose from less than one million tons in the early 1950s to more than 51 million tons in 2006. Multiple species of finfish, crustaceans, and mollusks are being produced around the world in intensive production systems. In China, aquaculture is the source of 90 percent of the food supplied by aquatic animals. Although aquaculture can reduce pressure on wild fisheries caused by overfishing, it may result in other unintended consequences. Some wild fish populations are depleted as they are harvested for use as feed for some farmed fish. Diseases have emerged as significant problems as a result of the high fish stocking densities common in intensive aquaculture. These diseases may devastate the farmed aquatic animals and spread to wild populations. Examples include sea lice, which have emerged as a problem in multiple locations, infectious salmon anemia in Chile, and white spot disease among shrimp in Asia.

Environmental Degradation

Environmental degradation includes deforestation, desertification, pollution, and climate change. The challenge of feeding the expanding human population puts pressure on natural resources and the environment. The conversion of marginal lands for food production often requires irrigation and can strain water supplies. Pressure for farmland expansion causes deforestation. The loss of trees leads to soil erosion, water runoff, and flooding. Human activity generates waste and pollution, which affects the air, water, and soil, and damages the health of people, animals, and plants. The natural habitat including tropical rainforests, old growth forests, coral reefs, and wetlands are also threatened by environmental degradation.

Climate Change

Humans and animals are directly impacted by climate change through altered weather patterns. They are indirectly impacted through changes in ecosystems, agriculture, industry, and the economy. Emerging evidence shows that climate change has altered the distribution of some infectious disease vectors. Shifts in weather patterns have been implicated in observed changes in the distribution of some tick vectors of disease, of some mosquito vectors in Europe and North America and in the phenology of some birds which are reservoirs of pathogens. A 2009 report in The Lancet stated that rising temperatures are likely to increase transmission of many infectious diseases, reduce supplies of food and clean water in developing countries and increase the number of people dying from heat-related conditions in temperate regions. The impact of climate change is greater in areas that already have endemic disease problems and less infrastructure to cope with current and future problems.

Interspecies Transfer of Pathogens

Increased production of food animals, habitat encroachment, environmental degradation, and climate change are all leading to increased transfer of infectious agents between species. When domestic animals are raised in novel environments, such as land near destroyed rain forests, both domestic and wild animals are exposed to species of animals and pathogens that they may not have encountered before. This can result in infectious agents being transferred to a new species. In their original hosts, these agents may be carried subclinically or produce only mild disease. However, pathogens may produce severe disease when they enter new hosts. As discussed earlier, interspecies transfer occurred in Malaysia when a large pig farm was established in an area with a high population of fruit bats. The Nipah virus was transmitted from the fruit bats to pigs, spread rapidly through the pig population, and was subsequently transmitted to people in close contact with the pigs.

Global Trade

Finally the global trade of products, including agriculture products, facilitates the transfer of infectious agents. The expansion of agricultural trade has helped provide greater quantity, wider variety, and better quality food to increasing numbers of people at lower prices. Approximately 25 percent of the world’s food production is traded globally. Both developed and developing countries have processes in place to control the import and export of food and agriculture products to meet sanitary and phytosanitary trade standards as mandated by the WTO. While these standards are important safeguards, not all animals or products carrying disease can be
stopped at the borders between countries. Animals and animal products smuggled between countries have caused disease outbreaks including exotic Newcastle disease in the U.S. and possibly the classical swine fever outbreak in the U.K. in 2000. Poultry smuggling may also contribute to the ongoing spread of the Asian strain H5N1 influenza viruses.

Wildlife trade is another important and often overlooked factor in potential disease transmission. Current estimates are that billions of live animals and animal products are traded globally each year. In the U.S. alone, over 500,000 shipments of wildlife containing 1.4 billion live animals have been imported since 2000. Nearly 80 percent of the shipments contain animals from wild populations, many of which have no mandatory testing for pathogens before or after shipment. Wildlife trade also introduces species of animals to new regions where they may compete with native species for resources or alter ecosystems.

Furthermore, migratory birds, wild animals, and insects cross international borders irrespective of import and export controls.

People also are constantly moving around the globe for business, tourism, or to immigrate to new areas. In 2008, there were 922 million international tourist arrivals around the world. These travelers may inadvertently carry and spread both human and animal diseases. Worldwide travel can dramatically increase the speed with which a disease is spread across international borders.

**Prospects for the Emergence of New Diseases**

All of the factors discussed above contribute to disease emergence/reemergence, and are reflective of ongoing trends and difficult to reverse. Addressing the economic, social, health, and environmental issues related to animal production will be one of the greatest political challenges in the 21st century. The fact that so many people depend on livestock and poultry for their livelihoods and as a source of food limits policy options, complicates local and global trade decisions, and raises political sensitivities. It is inevitable that the world will continue to experience the emergence of new human and animal diseases in the coming decades. This challenge mandates the need for the medical, veterinary, and public health communities to work together locally and internationally to protect human health, animal health, food safety, and food security.

Information Sources for this chapter can be found at: http://www.cfsph.iastate.edu/EEDATextbookReferences/