PUBLIC HEALTH

Pathogen Surveillance in Animals

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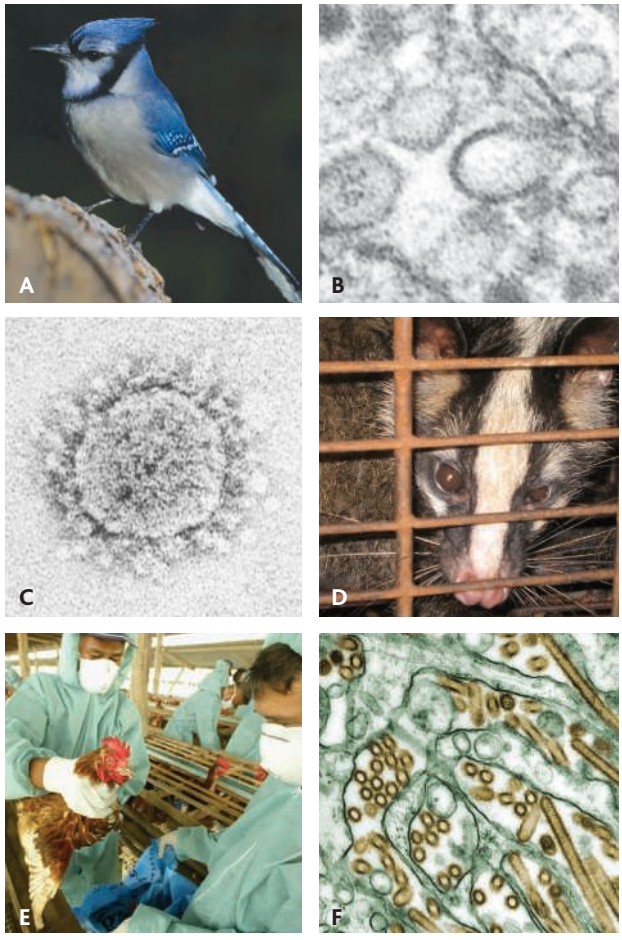
Emerging infections have an enormous impact on public health, food supply, economies, and the environment (table S1). Human mortality from recently emerged diseases varies, ranging from less than 100 people thus far for H5N1 avian influenza to about 20 million for AIDS (*1*). Livestock production has been negatively affected by the direct mortality of animals from emerging infections and depopulation policies to protect the safety of international trade and to control the spread of pathogens. The environmental impact of emerging infections is of special concern for endangered wild animal populations, which can be pushed to the brink of extinction by such events (*2*). Animals, and particularly wild animals, are thought to be the source of more than 70% of all emerging infections (*3*) (see figure, A to F, right; table S1). Therefore, surveillance in animals for zoonotic pathogens—pathogens of nonhuman vertebrate animals that may be transmitted to humans under natural conditions—is critical for managing these infections (*4*).

Currently, pathogen surveillance in animals is usually the responsibility of government departments of agriculture. Its quality varies greatly among countries and typically does not include wildlife. Internationally, a list of pathogens that affect international trade, including many important zoonoses, are reported to the World Organization for Animal Health (OIE) by its member countries (*5*). The recently restructured Animal Health Information System of the OIE includes an International Early Warning System through which member countries have agreed to report immediately any and all of six different defined categories of animal disease occurrences, and an International Monitoring System through which absence, presence, or changes in status of diseases listed by the OIE are reported every 6 months and additional information is reported annually.

Other international organizations involved in pathogen surveillance of animals include the United Nations Food and Agriculture Organization (FAO) and the World Health Organization (WHO). The International Society for Infectious Diseases, a nongovernmental organization, maintains the Internet-based Program for Monitoring Emerging Diseases (Pro-MED-mail), which regularly carries reports of new epidemiological events around the world. Pathogen surveillance in wild animals, where and when it occurs at all, is without clear international reporting conventions. The few existing surveillance systems generally focus on a limited number of animal species and pathogens (*6*, *7*). This information is collated annually from 167 countries by the OIE Wildlife Disease Working Group.

The current system does not provide a sufficient level of vigilance for several reasons. First, pathogen surveillance in domestic animals is generally confined to pathogens with known economic impacts. Second, pathogen surveillance in wildlife is less intensive to nonexistent, particularly in developing countries. Although some programs for wildlife exist, the number of species and geographical areas covered are very small compared with the many wild animal species (more than 15,000 species of mammals and birds alone) and their worldwide distribution. Finally, and most importantly, there is lack of integration among pathogen surveillance systems in humans, domestic animals, and wildlife. The sharp separation of the mandates of organizations charged with human and animal health management has encouraged total independence in their operations for a number of years. Below are some recent examples in which pathogen surveillance in animals, or its integration with public health, has faltered.

In November 2002, SARS first appeared in humans in southern China (*8*). The causative agent, a previously unknown coronavirus, was probably initially transmitted to humans by captive wild animals being sold as food (*9*) (see figure, C and D). No surveillance system was in place to detect pathogens in these marketed wild species. Thus, when the human pathogen was identi-



Emerging pathogens and their animal hosts. (**A**) A blue jay, one of the corvid species suffering high mortality from infection with West Nile virus, visualized (**B**) by transmission electron microscopy. (**C**) Negative contrast electron micrograph of SARS-associated coronavirus and (**D**) a masked palm civet, one of the species implicated in transmission of this virus to humans. (**E**) Culling of poultry infected with highly pathogenic avian influenza virus, subtype H5N1, shown (**F**) by transmission electron microscopy. Photo credits in (*16*).

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fied, there was no infrastructure or historic information available to guide and speed identification of potential wild animal reservoirs. There were no archived tissue samples or epidemiological records available from game farms on which some of these animals were raised, from the national and international trade routes along which they were moved from wild populations to urban markets, or from the markets themselves (*10*).

In February 2003, an outbreak of highly pathogenic avian influenza, subtype H7N7, occurred in poultry in The Netherlands (*11*, *12*) and spread to Belgium and Germany. Some 30 million chickens were destroyed. H7N7 influenza virus infection also was confirmed in 89 people, with one fatality (*11*). Phylogenetic analysis showed that the new strain most likely had originated from free-living ducks and had evolved into a highly pathogenic variant after introduction into poultry farms (*11*). Subsequent serological screening of the Dutch poultry industry showed that H7 influenza virus had been affecting the Dutch poultry industry several months before the major epidemic (*12*), but that its presence had not been recognized.

Since December 2003, epidemic influenza due to a highly pathogenic H5N1 virus strain has devastated the poultry industry in southeastern Asia (*13*) (see figure, E and F). As of 27 July 2005, H5N1 virus infection, mainly due to direct transmission from birds, had been confirmed in 109 people, of whom 55 had died (*14*). Although highly pathogenic avian influenza is listed by OIE as a disease requiring immediate reporting, the actual reporting of the successive outbreaks in this epidemic by various countries was slow in several instances, with documented delays as long as 7 weeks between recognition and international reporting (*13*). These delays contributed to the failure of regional and international organizations to contain or control this epidemic. The delays in reporting are likely due in part to the fact that the reporting authorities in some countries have dual and conflicting mandates both to report disease occurrences and to foster their country's export status for animal products.

The main players in global health management are the WHO, FAO, and OIE. The interrelatedness of animal and human health in the 21st century is drawing these formerly independent organizations together as never before. The ongoing avian influenza outbreak in Asia's poultry, combined with the constant threat of a human influenza pandemic, has provided the momentum to join forces against this disease. This is exemplified by the recent formation of an OIE/FAO Network of Expertise on Avian Influenza (OFFLU), which will work in collaboration with the WHO Influenza Network; the Global Strategy for the Progressive Control of Highly Pathogenic Avian Influenza, written by FAO and OIE in collaboration with WHO; and the FAO/OIE/WHO Consultation on Avian Influenza and Human Health, which proposed risk reduction measures for producing, marketing, and living with animals in Asia. Having demonstrated its feasibility for avian influenza, these international organizations should now expand this joint approach to zoonotic pathogens in general.

We recommend the creation of a joint expert working group either under the auspices of or with representation from the WHO, FAO, OIE, and other key stakeholders such as the World Conservation Union (IUCN). The mission of this expert working group should be to design and implement a global animal surveillance system for zoonotic pathogens that gives early warning of pathogen emergence, is closely integrated with public health surveillance, and provides opportunities to control such pathogens before they can affect human health, food supply, economies, or biodiversity. Canada's National Wildlife Disease Strategy, which aims to manage existing and emerging diseases that originate from wild animals, might serve as a useful template to develop such a system (*15*).

The tasks of the expert working group should include identifying the largest gaps in current surveillance systems in humans, domestic animals, and wildlife and determining the most cost-effective methods to fill them (e.g., sampling of animals at live animal markets, game farms, and ports of entry; establishment of systems for adequate preservation of samples from site of collection to the laboratory); identifying political barriers to effective surveillance (e.g., conflicting mandates of responsible authorities) and determining methods to deal with them appropriately (e.g., an international program of insurance against economic losses that may be triggered by rapid and transparent reporting); determining practical ways to integrate human and animal surveillance at the national and international level (including data management, communication networks, and regional laboratory networks); facilitating development and distribution of validated diagnostic tests for rapid and sensitive screening of samples for zoonotic pathogens in the full range of potential host species; and encouraging scientists and funding agencies to study the underlying mechanisms of disease emergence in order to find new methods to deal with this problem.

We estimate the annual start-up costs for such a working group at US$4 to $5 million for the first 3 years, based on a core group of 10 people with broad knowledge of human, domestic animal, and wildlife health. Making use of the worldwide expertise in the relevant disciplines, this group would design and implement a global animal surveillance system for zoonotic pathogens. The costs of this system would depend in part on the risk that human society is willing to take, but would be only a fraction of the savings made by early detection and rapid response to emerging pathogens. Zoonotic pathogens do not respect national borders, so it is in the best interests of wealthy nations to invest in improved animal surveillance programs in all parts of the world.

Emerging diseases are a major challenge to the biological safety of the world in the 21st century. Renewed effort, resources, and scientific innovations, as well as new degrees of integration are required to meet this challenge. Linking comprehensive pathogen surveillance of wild and domestic animals—the principal source of emerging infections—with public health surveillance at the national and international level, and improving the quality and coverage of these surveillance programs, will make an important and essential contribution to the detection and control of emerging zoonotic infections.

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