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SYMPOSIUM

Emerging Diseases at the Interface of People, Domestic Animals, and Wildlife. The Role of Wildlife in our Understanding of Highly Pathogenic Avian Influenza

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INTRODUCTION

The Wildlife Conservation Society (WCS) operates five parks in New York City, including the zoos at Central Park, Queens, and Prospect Park, the New York Aquarium and the Bronx Zoo. In addition, WCS manages some 400 conservation projects in 60 countries around the world. The commitment to the well-being of animals in zoos and to the conservation of critical landscapes around the globe provides a unique and robust set of competencies to provide critical health care programs that work to ensure the health of people, domestic animals, and wildlife. This was clearly demonstrated in 1999, when veterinary pathologists of the WCS were the first to connect the deaths of people, wild free-ranging birds, and zoo birds to a new disease to the Western Hemisphere. With samples from the WCS wildlife health surveillance program, the disease was confirmed to be West Nile virus.

The Field Veterinary Program (FVP) of the Wildlife Health Sciences Unit of WCS is active on four continents and performs community-based wildlife population health monitoring and surveillance. This on-the-ground commitment to assessing the long-term health of wild populations provides critical information that can serve as an early warning system for the emergence of new and renewed pathogens at the rural wildlife interface as well as the regional urban marketplace. It has been WCS FVP teams that provided the observations and samples that confirmed that gorillas were dying of Ebola virus in central and west Africa. During recent years, the broad disease surveillance techniques of the FVP have provided a baseline of information on the health of mammals,

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birds, and reptiles in various parts of the world.

Low pathogen avian influenza (LPAI) is endemic in wild migratory waterfowl populations. Best theories suggest that LPAI H5N1 moved from wild birds to domestic fowl, and in 1997, highly pathogenic avian influenza (HPAI) H5N1 was first identified as a disease of domestic fowl that spread to people in close contact with them in Hong Kong. The resurgence of this disease in Southeast Asia in 2004 brought a new wave of poultry and human deaths. One must study the cultural and agricultural practices in Asia to understand how this disease might mutate to a highly pathogenic form in domestic fowl, how it might spread to humans, and how it might jump back to wild migratory waterfowl. Religious practices, such as merit bird releases, bring people and passerine birds into intimate contact. The popular practice of cockfighting results in people moving these birds across vast regions and caring for injured cocks, which then results in human contact with bird blood and body fluids. It is common practice for people in rural areas to live in close proximity with their domestic animals, often times sharing room in the home or nearby. It is a typical scene to see cattle, ducks, chickens, and pigs living in or very near a family dwelling. The methods in which ducks are raised can include providing access to recently harvested rice paddies, where mixing with wild birds is commonplace. The aquatic environment is an excellent media for the persistence of viable avian influenza virus.

The trade in wild animals is a multi-billion dollar global operation. The animal markets or "wet markets" of Asia are a mixing bowl of domestic animals, wildlife from near and far, and people. Most often, sanitation and hygiene are very poor to nonexistent, and both people and animals are under a tremendous amount of stress, lowering immuno-competency. Those in the marketplace are handling live birds and butchering others without any personal protection and often live, eat, and sleep in their shops amongst their animals for sale. This serves as an excellent environment in which pathogens can mutate and jump into novel species. While it is uncertain that civet cats were the source of severe acute respiratory syndrome (SARS) in the Guangdong markets of China, it is clear they carried the disease. Since initial findings implicated civet cats, other species, such as domestic cats and fruit bats, have been shown to harbor the virus.

The FVP has been performing surveillance of wild bird populations for some 15 years in selected landscapes around the globe. Our work has demonstrated low pathogenic strains of avian influenza as far south as the Falkland Islands. In August 2005, a multi-disciplinary team comprised of FVP field veterinarians and Mongolian scientists performed field surveillance research in nine different sites along the migratory waterfowl flyway in Mongolia, including Erhel Lake, where a bird die-off was reported. At these nine sites, 850 fecal samples were collected, including 433 samples at Erhel Lake. All birds sampled were identified as to species and this information recorded. All species at a given location were identified and individuals counted so prevalence rates could be calculated. No virus was detected in live bird fecal culture samples. Six dead birds were necropsied. HPAI H5N1 was isolated from a whooper swan on Erhel Lake. The organism was isolated from samples provided to the United States Department of Agriculture ARS Poultry Laboratory in Athens, Georgia. The H5N1 isolate was determined to be a Clade II strain and selected by the World Health Organization and Centers for Disease Control and Prevention to be included in the research efforts to produce a human vaccine.

The results of this work suggest that the HPAI H5N1 has entered the migratory waterfowl flyway. The fact that the vast

majority of birds appeared healthy and their fecal cultures were negative also suggests that the prevalence of virus is low. Further, the observation that sick birds died and one of these few animals had H5N1 raises the question as to whether the migratory birds in this surveillance project were highly competent carriers of the organism. Further work must be performed to determine if there is a species of wild bird that can carry the disease for long distances. If wild birds prove to die precipitously from the disease, then wildlife birds are not likely the source of spread for HPAI H5N1, but rather one must consider other sources for spread into domestic poultry populations. These sources could easily be domestic poultry or the vast number of animals moving through the trade in domestic animals and wildlife for meat and pets that are being placed into markets in distant and disparate sites. The most effective method of protecting people from contracting HPAI H5N1 is to educate them on proper sanitation and hygiene for themselves and their domestic poultry. Basic preventive methods such as hand washing and proper protective garb when handling poultry will greatly reduce the risk of spread to humans from animals. Killing wild birds will be an unsuccessful mitigation method. It will not halt the spread of this disease in domestic poultry and subsequently into those that are in close proximity to these animals.

It is most important to note that H5N1 is but one of many possible strains of avian influenza that might someday become a competent pathogen of people. In addition, avian influenza is but one of a plethora of diseases that might make the evolutionary jump from being an animal pathogen to becoming a human disease. We must begin to think more holistically about our approach to the health of people and animals. We must consider that all living things on this world are intimately linked and only by understanding the relationships can we begin to provide sound solutions to complex disease threats. Halting the trade in wildlife is a critically important step to lowering the risk of pathogens emerging from wildlife to domestic animals and people and will slow the loss of biodiversity on our planet.

ONE WORLD, ONE HEALTH

In recent years, outbreaks of diseases such as avian flu, severe acute respiratory syndrome (SARS), the Ebola virus, and mad cow disease have frightened the public, disrupted global commerce, caused massive economic losses, and jeopardized diplomatic relations. These diseases have also shared a worrisome key characteristic: The ability to cross the Darwinian divide between animals and people. None of these illnesses depends on human hosts for its survival; as a result, they all persist today, far beyond the reach of medical intervention.

Meanwhile, humanity has become vulnerable to cross-species illnesses, thanks to modern advances such as the rapid transportation of both goods and people, increasing population density around the globe, and a growing dependence on intensified livestock production for food. The global transport of animals and animal products, which includes hundreds of species of wildlife, also provides safe passage for the harmful bacteria, viruses, and fungi they carry, not to mention the prion proteins that cause insidious illnesses such as mad cow disease and chronic wasting disease in deer and elk.

Adding to the risks is the fact that while many people in the developed world would scarcely recognize meat if it did not come wrapped in clear plastic, the vast majority of people on the planet today still slaughter animals for meat themselves or buy it fresh, salted, or smoked in open-air markets. These markets generally go uninspected by health officials, and consumers rarely have access to good health care,

education on hygiene, common vaccines, or antibiotics.

Not only is local and national health care often a problem, internationally no agency is responsible for, or capable of, monitoring and preventing the myriad diseases that can now cross the borders between countries and species. More specifically, no organization has the mandate to pursue policies based on a simple but critically important concept: That the health of people, animals, and the environment in which we all live are inextricably linked.

Thus, for example, the U.S. Department of Agriculture works to protect only the United States livestock industry and has scaled back the attention it pays to animals outside the United States over the last two decades. Despite new concerns about terrorist attacks on the U.S. food supply, Washington has still made little attempt to research and reduce diseases overseas before they reach U.S. shores. Nor does the United Nations direct the resources necessary to do a better job. The U.N. Food and Agriculture Organization, for example, is mandated to monitor the production of livestock and crops but does little to track threats to and dangers from wild plants and animals. The World Animal Health Organization has a volunteer committee that considers wildlife-related diseases, but it consists of just six people and meets only three days a year. And the World Health Organization (WHO) can only get involved in a country if officially invited, leaving it helpless to intervene in countries with governments that either do not know about or do not want to reveal the presence of a disease within their borders. The U.S. Centers for Disease Control and Prevention (CDC) must similarly wait for an invitation before extending its reach outside the United States.

What all this means is that no government agency or multilateral organization today focuses on the numerous diseases that threaten people, domestic animals, and wildlife alike. Nor does any one body collect and collate data from across the scientific spectrum to ensure that health solutions are based on the input of professionals from all the various health fields working with humans, domestic animals, and wildlife.

Yet diseases pay no regard to the divisions among species or academic disciplines, and the failure to recognize this truth is placing humanity in great peril. As a recent outbreak of avian influenza reminded the world, what happens in one part of it — and to one species — can have a deadly serious impact on others. The planet clearly needs a new health paradigm that not only integrates the efforts of disparate groups but also balances their respective influences to help bridge the gaps between them. This is especially so since the immediate effects of a particular illness are often the least of the problem. Diseases that attack people and animals also cause poverty and civil unrest, disrupt "free" ecosystem services such as drinking water and plant pollination, and threaten otherwise well-planned and sustainable economic development efforts, such as low-impact tourism. In short, the failure to adopt a planetwide and cross-species approach to health is getting costlier by the day; humanity cannot afford to pay the price much longer.

THE WORLD WE WERE GIVEN

According to recent analysis, more than 60 percent of the 1,415 infectious diseases currently known to modern medicine are capable of infecting both animals and humans. Most of these diseases (such as anthrax, Rift Valley fever, bubonic plague, Lyme disease, and monkeypox) are "zoonotic," meaning they originated in animals but have crossed the species barrier to infect people. The others, which receive less attention, are "anthropozoonotic," meaning they are typically

found in humans but can and do infect animals as well (examples include the human herpes virus, tuberculosis, and measles). Dividing infectious agents into these two groups is convenient for teaching purposes. But it overlooks the critically important fact that all of them can move back and forth among species, mutating and changing their characteristics in the process. Avian influenza — which started in birds but is now infecting humans as well — has recently highlighted the need for a more holistic view of disease.

It is probably just luck that has so far allowed scientists to maintain these distinctions. One of the greatest medical success stories of the last century was the eradication of smallpox. But this achievement was largely due to the fact that smallpox survives in only one host species, namely humans. If even one more type of animal had been able to harbor the disease, there is a good chance that eradication would not have been accomplished, despite the Herculean global effort. When a pathogen can find refuge or a place to mutate in a range of hosts, controlling it becomes far more complex, requiring an integrated — and much more difficult — approach.

To get a sense of the breadth and the seriousness of the issue, consider HIV/AIDS, which most scientists now think arose in Africa as a result of the human consumption of primates that were infected with simian immunodeficiency viruses. Or consider the Ebola virus, which has a similar history. The disease first came to international attention in 1976, when it appeared around the Ebola River in what was then called Zaire. The virus infects people, gorillas, chimpanzees, and monkeys, causing severe internal and external hemorrhaging and leading to death in up to 90 percent of its human victims. Human infection spreads quickly, especially via caregivers and people who flee an area to escape the illness. Since the disease first appeared, successive human outbreaks have been recorded in Côte d'Ivoire, Gabon, Sudan, and Uganda. But humans have not been the only victims; lowland gorillas and chimpanzees in Gabon and Congo and chimpanzees in western equatorial Africa have been decimated by the sickness. Other forest animals, such as duikers (small antelopes) and bush pigs may also be affected. When subsistence hunters discover a sick or dead animal in the forest, they view it as good fortune and bring it home to feed their families or trade with their neighbors. The Ebola virus then easily infects those handling the meat, and a chain of contacts and infections ensue. Each of the human outbreaks in central Africa during the late 1990s and the first years of this century was traced to humans handling infected great apes.

SARS also arose from contact with wild animals. The illness first appeared in late 2002 in China's Guangdong Province, where people began complaining of high fever, cough, and diarrhea, and eventually developed severe pneumonia. The unknown disease was very contagious; within a matter of weeks, a visitor to Hong Kong helped spread it to five continents. By July 2003, the WHO had tallied 8,437 cases and 813 deaths. Due mostly to a lack of understanding of the new disease, global travel and trade were disrupted as fear spread.

After four months, scientists eventually discovered that the mystery disease was caused by a coronavirus (a family of viruses found in many animal species). The virus, in turn, was traced back to a small mammal called the palm civet, which is farmed in the Guangdong region and sold for human consumption. Later, evidence of the virus was also found in raccoon dogs, ferrets, and badgers being sold in Guangdong's wildlife markets, as well as in domestic cats living in the city. Epidemiological studies confirmed that the first human infections had indeed come through animal contact, although the

exact species responsible has not been definitively identified.

In the months after SARS first appeared, the Chinese government closed down its live wildlife markets. Within 10 days of linking the disease to the wild animal trade, the government also confiscated close to a million animals, many of which had been brought into the area from other parts of the world and which hosted a variety of exotic viruses and bacteria. But the damage had already been done. Prior to the government action, the animals were often housed together, exposed to one another's waste, and sometimes even fed to one another. For a virus or bacteria capable of jumping between species, the markets had provided the perfect place to reproduce.

THE WORLD'S NOT FLAT, IT'S A MIXING BOWL

China, however, is far from the only country where people risk infection from animal-borne diseases. The West is also in danger, as was discovered in late May 2003, when the first cases of a mysterious illness were reported in hospitals in Illinois, Indiana, and Wisconsin. Patients, many of whom had been in close contact with pet prairie dogs, started coming down with skin ulcers and fevers. It was soon discovered that a prairie dog dealer in Wisconsin had let a number of his animals mix with rodents recently imported from Ghana that happened to be carrying the monkeypox virus. An animal distributor had then sold the infected prairie dogs to pet stores in Milwaukee and at an animal swap meet in northern Wisconsin. Within about a month, 71 human cases of monkeypox in six Midwestern states had been reported to the CDC; luckily, no one died.

It remains unknown how or where waste from the infected prairie dogs was dumped or whether owners released any infected prairie dogs into the wild during the scare. Moreover, U.S. laws remain dangerously lax. At the time of the monkeypox outbreak, it was legal to import any nonendangered African rodent into the United States as a pet — despite the fact that the risk of bringing in foreign diseases in the process was predictable and could have been avoided through international surveillance and information-sharing programs. (Wildlife health experts and human health workers in central Africa have long associated human monkeypox infections with rodent and squirrel contact.) Since the U.S. outbreak, Washington has imposed restrictions on the import of African rodents, but it remains legal to bring in rodents from other continents, and many other species from around the world continue to be shipped into the United States and many other countries, largely without oversight.

Determining the exact scale of the global wildlife trade is impossible, since the operations range from the extremely local to the international, and are often illegal and informal. Part of the picture, however, can be glimpsed from figures compiled by the Wildlife Conservation Society from a variety of sources. According to these numbers, the annual global trade in live wild animals includes roughly 4 million birds, 640,000 reptiles, and 40,000 primates. Following the SARS outbreak that began in 2002, the Chinese government reportedly confiscated 838,500 wild animals from the markets of Guangdong. But every year, tens of millions of wild mammals, birds, and reptiles continue to flow through these and other trading centers, where they make contact with humans and dozens of other species before being shipped elsewhere, sold locally, or sometimes freed back into the wild — often carrying new and dangerous pathogens. The number of these animals that end up as food is staggering; indeed, experts estimate that in central Africa alone, consumers eat 579 million individual wild animals a year, for a total of more than a billion kilograms of meat.

Meanwhile, people in the Amazon basin are thought to consume between 67 and 164 million kilograms of wild animal meat a year, accounting for between 6.4 million and 15.8 million individual mammals alone.

Before these animals (with whatever diseases they may be carrying) are eaten, they encounter — and possibly transmit pathogens to — hunters and marketers. They also risk infecting domestic animals and wild scavengers in villages and market areas that consume the remnants and waste of wildlife eaten by humans. All considered, at least a billion direct and indirect contacts among wildlife, humans, and domestic animals result from the handling of wildlife and the wildlife trade annually.

Such contact does not just endanger humans and their pets; the pathogens inadvertently transported around the globe can also devastate local wildlife, disrupting the environment and causing enormous economic harm. In October 2004, avian flu (specifically, the H5N1 type A influenza virus) was detected in two mountain hawk-eagles that were smuggled from Thailand into Belgium in airline carry-on baggage. Last year, another deadly virus entered Italy via a shipment of Pakistani parrots, lovebirds, and finches. Chytridiomycosis, a fungal disease responsible for the extinction of 30 percent of the world's amphibian species, has been spread by the international trade and subsequent release of African clawed frogs (a popular laboratory animal). Tuberculosis originating from domestic cattle has now infected herds of wild bison in Canada, deer in Michigan, and cape buffalo and lions in South Africa. In 1999, rinderpest, a disease originally introduced to Africa by the importation of domestic cattle from India, killed more wild buffalo in Kenya than had been slain by poachers during the previous two decades.

The increasing movement of animals and humans around the world and their greater exposure to the many diseases that dance between them have also placed domesticated livestock at increasing risk. This is especially so since the ravenous international demand for animal meat has turned livestock production into an ultraintensive industry, with swine, poultry, and cattle operations now packing huge numbers of animals into limited spaces. Moreover, projections by the International Food Policy Research Institute indicate a doubling of animal production in developing countries over the next 20 years. Although modern factory-farm practices maximize food production, they also make livestock more susceptible to illness. Infection spreads quickly through crowded animal pens, and growing antibiotic resistance makes fighting disease more difficult. Many farms now routinely mix antibiotics with animal feed to avoid transmitting illnesses, and selective breeding for specific traits often predisposes animals to conditions requiring repeated antibiotic treatment. Such increased antibiotic use is helping to create dangerous drug-resistant superbugs that may endanger both animals and humans.

High-volume food production has also prompted the livestock industry to adopt other dangerous practices, which have already led to at least one high-profile disaster: the outbreak of bovine spongiform encephalopathy (BSE), or mad cow disease, in the United Kingdom. Mad cow disease is a chronic, degenerative disorder that affects the central nervous system of cattle. The disease, known as scrapie in sheep, had existed for hundreds of years without infecting other species. It only crossed over to cattle when British farmers started feeding infected sheep byproducts to their herds in the 1980s. Once BSE jumped to cows, it started spreading rapidly, with 182,745 documented cases occurring between 1986 and 2002 in the United Kingdom. In response to the outbreak, European countries banned all imports of British cattle. But BSE has nonetheless been found in

Europe, Canada, and the United States since then. It has also jumped to people, and a new human variant of the illness, known as Creutzfeldt-Jakob disease, is believed to be responsible for 150 deaths since 1995.

Malaysia has also fallen victim to a disease spread by new farming techniques. The Nipah virus appeared in the country's pig and human populations in 1998, killing 105 people and forcing the Malaysian government to cull more than 1 million pigs to stop the spread. Five species of fruit bats were also found to carry the virus, suggesting a wide prevalence of the pathogen among healthy bats. It seems that people acquired the virus from handling infected pigs, which contracted the disease from bats feeding in fruit trees standing in newly developed pig farms.

The Nipah outbreak highlights what can happen when people and domestic animals modify previously undisturbed wild habitats. Within natural ecosystems, microbes and wildlife tend to exist more or less in balance. But the introduction of new species — such as cows, pigs, dogs, or humans — can allow pathogens to jump into these new hosts, which may have no natural immunity or evolved resistance. The results, predictably, can be devastating.

In addition to the direct health damage they have caused people and animals, animal-related pathogens have destabilized international trade and caused hundreds of billions of dollars of economic damage globally. The report of the U.S. National Intelligence Council's 2020 Project, "Mapping the Global Future," has identified a global pandemic as the single most important threat to the global economy. In early 2003, the U.N. Food and Agriculture Organization reported that more than one-third of the global meat trade was being embargoed as a result of mad cow disease, avian influenza, and other livestock illnesses. According to Bio Economic Research Associates, the rash of emerging or re-emerging livestock diseases that have cropped up around the world since the mid-1990s (illnesses that include mad cow disease, foot-and-mouth disease, avian influenza, swine fever, and others) has caused losses of an estimated $100 billion; SARS alone cost the global economy half that amount. The pain caused by such crises, moreover, has spread far beyond those responsible; wildlife market traders were not the ones who paid for the SARS outbreak, and the African rodent importer in Texas did not reimburse the United States and local governments for the millions of dollars spent to contain monkeypox in 2003.

Nor can these dollar figures adequately reflect the often devastating effect outbreaks can have on some of the poorest people on the planet. Since 2003, for example, efforts to control the spread of avian influenza in Asia have required the culling of more than 140 million chickens. In countries such as Thailand and Vietnam, the vast majority of these animals were not owned by large, industrial producers, but by small farmers and peasants. Losing their livestock was painful indeed, especially since financial compensation schemes for rural poultry owners are rare to nonexistent in much of Southeast Asia. Not only did this lack of compensation increase the damage done by the disease; it also created a serious disincentive for bird owners to report suspicious illnesses among their flocks.

RISING TO THE OCCASION

As many of these examples suggest, preventing or controlling future outbreaks of animal-borne diseases and mitigating their impact will require a far broader approach than has so far been attempted by the generally isolated health systems of highly developed countries. Too often, the global response to new pathogens has been driven by fear, which has only magnified the economic and other costs of disease control.

That said, a few brave individuals have already begun the process of creating a new international and interdisciplinary approach to disease control. Working in some of the most remote places on earth, they have slowly established knowledge-sharing networks, such as the World Conservation Union's Veterinary Specialist Group. And their contributions have already been significant. For example, when avian influenza first appeared, much attention was mistakenly directed at controlling its spread among wild birds in Northeast and Southeast Asia. It was these new informal participants in health discussions — such as conservation biologists and veterinarians working with the Wildlife Conservation Society in Cambodia and linked to staff at the Food and Agriculture Organization — who were the first to point out that the migratory routes and timing of wild birds did not actually correspond with the spread of the disease and that domestic birds were more likely the culprit. Without this insight, valuable resources would have been wasted trying to control the disease among the wrong animal population.

As important as such contributions have been, however, many individuals trying to develop a new global approach to health-care work for nongovernmental organizations or for local governments lack the resources and a larger, formal network that could fill in the gaps in health care as it relates to wildlife and humanity. Were their resources improved, the results would be enormously beneficial; building bridges across disciplines to solve health problems can have simple but profound effects.

For example, studies in South America have shown that contrary to common opinion, livestock diseases pose many more threats to wildlife than the other way around. In much of the world, reducing disease in domestic animals would benefit several industries, improve human health and livelihoods, and help safeguard wild animals. As this suggests, strategically increasing protections in one area of health care can benefit another. For example, gorillas and chimpanzees in central Africa have little to no immunity to common human diseases, and so they are endangered by contact with local people and tourists. This risk could be dramatically reduced by implementing good preventive health programs and practices in local villages, which would benefit both people and wildlife. Already, work with the Ebola virus in gorillas and chimpanzees has shown that investments in wildlife health can protect urban human populations; in Africa, animal health workers detected the presence of Ebola in wildlife months before the first human cases occurred, providing critical lead-time to warn villagers not to hunt or handle the animals that were a source of the infection. Such a broad, “one health” approach to disease can be much more effective and inexpensive than the traditional “quarantine and stamping out” strategy for fighting an illness after an outbreak has already begun. Specialists in human and animal health, in conjunction with wildlife conservation professionals, have already developed a set of guiding concepts on these themes, called the Manhattan Principles. But the ideas still need much broader acceptance to be more effective.

To further improve the chances of heading off and limiting the effect of animal-related diseases, a number of additional steps are necessary. To begin with, better worldwide surveillance to detect infectious diseases among wildlife is needed to improve response time and reduce the costs of new outbreaks. Such surveillance differs from traditional hypothesis-driven disease research because it involves very broad searching rather than attempts to answer a highly focused question. Investment in gathering advance information can pay off handsomely; early warning of how diseases work and of their normal characteristics among animals can help limit the damage when the illnesses start to spread.

New public-private partnerships could also be hugely helpful. Currently, the failure of public-sector programs to comprehensively monitor, prevent, and respond to unusual diseases is being compensated for by the private sector. Coordination between these efforts and governments remains limited — in some cases due to regulations and restrictions that prevent such collaboration. For example, under its agreement with member states, the World Animal Health Organization cannot accept information on wildlife diseases in a country unless that information has been submitted officially by a national agricultural authority — few of which are mandated or organized to monitor wildlife diseases. These policies should be reformulated to facilitate cooperation among governments, corporations, and nonprofit organizations, and formal mechanisms for sharing information should be established.

It would also help to shift responsibility for the costs of outbreak prevention and control to animal traders, since this would provide them with incentives for reducing disease and would lower the costs of disease surveillance, control, and prevention by third parties. One way to force traders to shoulder more of the costs would be to require them to buy disease outbreak insurance on all animal imports or shipments. Doing so would discourage dangerous activities among animal traders by hitting them where it hurts: in their wallets.

Financial incentives are not enough, however; the World Trade Organization and other appropriate international bodies must also start requiring governments to better regulate the health aspects of international trade in wild and domestic animals. Individual states also need to implement new laws to prevent the spread of diseases within their borders. There is now plenty of evidence to suggest that human trade and consumption of wildlife have led to global health disasters; governments must therefore immediately start making serious efforts both to reduce and to regulate properly the trade of such animals internationally, regionally, and even locally.

On the health-care side, decisions still tend to be made without sufficient input from all appropriate stakeholders. For example, the decision of a Southeast Asian government in 2004 to control avian influenza by culling wild migratory birds failed to identify the real source of the problem (domestic livestock) or to recognize that the wild birds were protected by at least two separate international conventions. Involving experts in public health, agriculture, and environmental conservation, as well as legal counsel, in such decisions would help governments avoid repeating these mistakes and adopt more sound strategies in the future.

Finally, greater bilateral and multilateral aid is needed for efforts to gather, evaluate, and share information on infectious diseases that affect the wide range of living organisms present around the world. Too often, health experts focus on human health and agriculture alone, missing a huge part of the picture. More money must be spent on initiatives that include wildlife health and conservation in discussions of human health care; more money would also help stimulate the development of holistic efforts in areas of the world where they are most critically needed.

The obstacles to identifying, understanding, and sharing information about all infectious diseases on the planet may appear daunting. But they are no excuse for not trying. New, holistic approaches should be started at local and regional levels; such efforts are already proving efficient and cost-effective and are advertising the benefits of the new paradigm. Such small- and medium-scale efforts can be built up over time and run in parallel with higher-order, global coordination.

The time to launch such initiatives is now, before the next global pandemic occurs. Bridges must be built between different scientific disciplines, and trade in

wildlife must be dramatically reduced and, like the livestock industry, properly regulated. Global health will not be achieved without a philosophical shift from the expert-controlled, top-down paradigm that still dominates both science and medicine. A broader, more democratic approach is needed, one based on the understanding that there is only one world — and only one health.

REFERENCES

1 Karesh WB, Cook RA. The Human-Animal Link. Foreign Affairs 2005;84(4):38-50