S NCBI Resources ☑ How To ☑ Sign in to NCBI PMC Search US National Library of Medicine Advanced Journal list Help National Institutes of Health COVID-19 is an emerging, rapidly evolving situation. ❶ Get the latest public health information from CDC: <a href="https://www.coronavirus.gov">https://www.coronavirus.gov</a>. Get the latest research from NIH: https://www.nih.gov/coronavirus. Journal List > Emerg Infect Dis > v.13(1); 2007 Jan > PMC2725831 Formats: **EMERGING** Article | PubReader | ePub (beta) | PDF (187K) | Citation **INFECTIOUS DISEASES Share** Facebook Twitter Google+ PMCID: PMC2725831 Emerg Infect Dis. 2007 Jan; 13(1): 6–11. doi: 10.3201/eid1301.060480 PMID: <u>17370509</u> Save items Add to Favorites Wildlife, Exotic Pets, and Emerging Zoonoses<sup>1</sup> Bruno B. Chomel, Albino Belotto, and François-Xavier Meslin and Similar articles in PubMed ► Author information ► Copyright and License information <u>Disclaimer</u> The role of wildlife in emerging and re-emerging zoonoses. [Rev Sci Tech. 2004] This article has been <u>cited by</u> other articles in PMC. Bats and emerging zoonoses: henipaviruses and SARS. Field HE. Zoonoses Public Health. 2009 Aug; 56(6-7):278-[Zoonoses Public Health. 2009] 84. **Abstract** Public health threat of new, reemerging, and neglected zoonoses in the industrialized world. [Emerg Infect Dis. 2010] Most emerging infectious diseases are zoonotic; wildlife constitutes a large and often unknown reservoir. [Zoonoses with wildlife reservoirs: a threat to public health and the Wildlife can also be a source for reemergence of previously controlled zoonoses. Although the discovery of economy]. [Rev Med Chil. 2008] such zoonoses is often related to better diagnostic tools, the leading causes of their emergence are human One health: zoonoses in the exotic animal practice. behavior and modifications to natural habitats (expansion of human populations and their encroachment on [Vet Clin North Am Exot Anim Pr...] wildlife habitat), changes in agricultural practices, and globalization of trade. However, other factors See reviews... include wildlife trade and translocation, live animal and bushmeat markets, consumption of exotic foods, See all... development of ecotourism, access to petting zoos, and ownership of exotic pets. To reduce risk for emerging zoonoses, the public should be educated about the risks associated with wildlife, bushmeat, and exotic pet trades; and proper surveillance systems should be implemented. Cited by other articles in PMC Infectiologie itinérante **Key words:** Emerging zoonoses, wildlife, ecotourism, exotic pets, synopsis [Antibiotiques (Paris, France :...] Migratory Polyarthralgias and Skin Rash: Rat Bite Fever with a Emerging and reemerging infectious diseases have received increasing attention since the end of the 20th Positive Anti–Cyclic Citrullinate [Mayo Clinic Proceedings: Innov...] century. An estimated 75% of emerging infectious diseases are zoonotic, mainly of viral origin, and likely Zoonotic and vector-borne pathogens in tigers from a wildlife to be vectorborne (1). The emergence and rapid spread of West Nile virus in North America and the safari park, Italy [International Journal for Para...] monkeypox outbreak in pet prairie dogs have been major awakening public health events that underscored Editorial the need for closer collaboration between the veterinary profession, wildlife specialists, and public health [Comparative Immunology, Microb...] personnel (2,3). These events emphasized the role that veterinarians and other wildlife specialists can play Towards a conceptual framework to support one-health research in surveillance, control, and prevention of emerging zoonoses, as their training in disease recognition and for policy on emerging zoonose [The Lancet. Infectious Disease...] population medicine makes them well suited for early detection networks (4). See all... Infectious pathogens of wildlife affect not only human health and agricultural production but also wildlifebased economies and wildlife conservation. Zoonotic pathogens that infect domestic animals and wildlife Links hosts are more likely to emerge (5). Furthermore, our quest for close contact with wild animals and for Cited in Books exotic pets puts us at risk for exposure to zoonoses. MedGen Emerg Infact **Economic Effects of Wildlife PubMed** Go to: 💟 Taxonomy Wildlife is a major source of income, either directly for consumptive or productive use value or indirectly for touristic and scientific values (6). For instance, wildlife tourism is among the top exporting activities of Tanzania and Kenya and generates an annual income of approximately half a billion US dollars (6). Even **Recent Activity** in industrialized countries, wildlife-related activities can generate major income. In the United States, the Turn Off Clear total expenditure for wildlife-related activities was \$101 billion in 1996, ≈1.4% of the national economy Wildlife, Exotic Pets, and Emerging Zoonoses (6). Hunting activities for the 10 million hunters in Europe generate a financial flux of almost 10 billion euros and  $\approx$ 100,000 jobs. Europe is also the world's largest importer of venison (>50,000 tons/year). Hypoxia in the thymus: role of oxygen tension in thymocyte Similarly, in the United States, hunting activities generate >700,000 jobs (6). In Africa, the bushmeat trade survival. PubMed is generating hundreds of millions of dollars ( $\mathcal{I}$ ). In the Congo Basin, trade and regional consumption of Viruses and prions of Saccharomyces cerevisiae wild animal meat could reach 4.5 million tons annually; the demand for bushmeat in western and Central Africa could reach up to  $4\times$  the demand for bushmeat in the Amazon Basin (8). Worldwide, deer farming Focused Teaching Improves Medical Student Professionalism has been developing dramatically. In New Zealand, ≈2 million farmed deer, half of the world's farmed deer and Data Gathering Ski... population, generate an annual income of NZ \$200 million (6). Radiofrequency radiation injures trees around mobile phone base stations. PubMed Human Population Expansion and Encroachment on Wildlife Habitat Go to: 🗹 See more... The exponential growth of the human population, from  $\approx 1$  billion in 1900 to 6.5 billion in 2006, has led to major ecologic changes and drastic wildlife habitat reduction. Many examples of the emergence or reemergence of zoonoses related to human encroachment on wildlife habitats exist. Deforestation, development of human habitat, and mining activities have been suggested as risk factors Epidemiologic situation of human rabies in Latin America in [Epidemiol Bull. 2005] 2004. associated with the reemergence of vampire bat rabies in humans in the Amazon Basin. In 2004, 46 persons died of rabies transmitted by vampire bats, mainly in Brazil (22 cases) and Colombia (14 cases); only 20 human cases of rabies were transmitted by dogs in all Latin America ( $\underline{9}$ ). A similar trend was again observed for 2005. When first described in 1957, Kyasanur Forest disease was restricted to a much smaller area (300 square miles) in India than the actual 2,000 square miles of endemic zone (10). This tickborne disease occurs in evergreen rain forests interspersed with deciduous patches and clearings for rice cultivation and human habitations. Forest workers are particularly at risk; their mortality rates may reach 10%. In 1983, a major epidemic occurred during which several monkeys died, 1,555 humans were infected, and 150 humans died. The outbreak occurred in previously undisturbed forest where some 400 ha were clearcut to establish a cashew tree plantation. Most of the human patients were immigrant laborers employed to clear the forest Emerg Infact (10). As many as 1,000 human cases occur each year, and this number has increased in the past 5 years. Most cases occur during the dry season (January–May), when nymphal activity is maximal. Such a zoonosis is a good example of deforestation and agricultural development leading to human habitat expansion into natural foci of a viral infection. Because cleared areas were widely used for grazing of cattle, a major host for adult ticks, these areas favored the proliferation of the tick Haemaphysalis spinigera. Conversely, the reduction of traditional agricultural land and its replacement with forested areas, home to Review Emerging bacterial zoonotic and vector-borne diseases. Ecological and epidemiological factors. [JAMA. 1996] the main reservoirs and hosts of Borrelia burgdorferi, in association with the settlement of persons in Wildlife diseases and population medicine. periurban areas led to a considerable increase in human cases of Lyme disease in the United States (11). An [J Am Vet Med Assoc. 1992] estimated 32.4 million wild ruminants, major amplifiers for adult Ixodes scapularis ticks, live in North America (12). An estimated 23–40 million white-tailed deer inhabited North America before the arrival of Europeans; the deer population was greatly reduced by habitat loss and unrestricted hunting. However, by the mid-20th century, the population was restored throughout North America, and an estimated 14-20 million white-tailed deer are believed to inhabit the United States alone. In many areas of the eastern United States, populations have soared to previously unattained levels Emay Intert (http://www.aphis.usda.gov/ws/nwrc/is/living/deer.pdf). Human activities may also be a source of wildlife infection, which could create new reservoirs of human Mycobacterium tuberculosis: an emerging disease of free-[Emerg Infect Dis. 2002] ranging wildlife. pathogens. The recent outbreak of tuberculosis caused by Mycobacterium tuberculosis in suricats and <u>무</u>. mongooses was one of the first documented spillovers of a human disease within a wildlife population (13). Banded mongooses were observed feeding regularly at garbage pits and were therefore exposed to human excretions and any infectious material from tuberculosis-infected humans. Changes in Agricultural Practices and Emergence of Wildlife Zoonoses Go to: 💟 The emergence of Argentine hemorrhagic fever in east-central Argentina during the 1950s, and its Review Arenaviruses other than Lassa virus. [Antiviral Res. 2003] expansion to north-central Argentina, has been directly linked to development of agricultural activities (mainly corn growing) that sustain the virus's main reservoir, the corn mouse (Calomys musculinus). Caused by the Junin virus, Argentine hemorrhagic fever affects primarily adult male agricultural workers, mainly during the harvest season (14). In the late 1970s and early 1980s, a rabies epidemic occurred in free-ranging greater kudus (Tragelaphus Rabies in the kudu antelope (Tragelaphus strepsiceros). [Rev Infect Dis. 1988] strepsiceros) in Namibia (15). The kudu population had increased considerably in response to favorable conditions and human-made environmental changes. Suitable conditions for transmission in the kudu Intert Dia population after initial infection by rabid carnivores are provided by the social behavior of kudus, such as browsing on thorny acacia trees and resultant lesions in the kudus' oral cavity, and excretion of relatively high titers of virus in the saliva of infected animals (15). The outbreak of Nipah virus infection in Malaysia during 1998–1999, which caused 265 human cases of Review Anthropogenic environmental change and the emergence of infectious diseases in wildlife. [Acta Trop. 2001] viral encephalitis and a 38% mortality rate, was also the result of several major ecologic and environmental changes associated with deforestation and expansion of nonindustrial pig farming in association with production of fruit-bearing trees (16). Such combination led to infection of pigs, which developed respiratory and neurologic symptoms after indirect exposure to infected fruit bats that shed the virus. The sick pigs were a subsequent source of human infection (16). Farming of wild animal species led to reemergence of zoonoses such as bovine tuberculosis in captive deer Advances in health and welfare of farmed deer in New Zealand. [N Z Vet J. 2002] populations. Deer at low population densities on natural range are less likely to be affected to any major Bovine tuberculosis and badger blame. extent by disease. However, disease becomes a factor in intensive management of deer (1.7). Reemergence [Lancet. 2006] of zoonotic diseases that had been controlled from their domestic animal reservoirs is also of major Review From the discovery of the Malta fever's agent to the Emary Infact Dia concern. Wildlife may become new reservoirs of infection and may recontaminate domestic animals; discovery of a marine mammal reservoir, brucell [Vet Res. 2005] examples include bovine tuberculosis in the United Kingdom associated with Mycobacterium bovis infection in badgers (Meles meles) (18) and brucellosis in outdoor-reared swine in Europe that resulted from spillover from the wild boar brucellosis (*Brucella suis* biovar 2) reservoir (1.2). Wildlife Trade and Translocation Go to: ₩ Wildlife trade provides mechanisms for disease transmission at levels that not only cause human disease Wildlife trade and global disease emergence. [Emerg Infect Dis. 2005] outbreaks but also threaten livestock, international trade, rural livelihoods, native wildlife populations, and Health concerns prompt US review of exotic-pet trade. ecosystem health (Z). Worldwide, an estimated 40,000 primates, 4 million birds, 640,000 reptiles, and 350 [Nature. 2004] million tropical fish are traded live each year (7). International wildlife trade is estimated to be a US \$6billion industry (20). Translocation of wild animals is associated with the spread of several zoonoses. Rabies was introduced in Review Disease risks associated with wildlife translocation [Rev Sci Tech. 1993] projects. the mid-Atlantic states in the 1970s when hunting pens were repopulated with raccoons trapped in rabies-Epidemiological surveillance of rabies in Lithuania from 1986 to endemic zones of the southern United States (21). In Eastern Europe, raccoon dogs (Nyctereutes 1996. [Rev Sci Tech. 1998] procyonoides) are becoming a new reservoir for rabies, in addition to the established red fox reservoir, as Review From the discovery of the Malta fever's agent to the Emary Infact Dis raccoon dogs have spread into new habitats from accidental release of animals raised for fur trade (22). discovery of a marine mammal reservoir, brucell [Vet Res. 2005] Brush-tailed possums (Trichosurus vulpecula) from Tasmania were introduced into New Zealand to establish a new species of fur-bearing animals. The translocated population proliferated and is now estimated to be >70 million, of which 3%–30% are possibly infected by M. bovis, a permanent threat to the cattle- and deer-farming industries (21). Translocation of hares from central and Eastern Europe for sporting purposes led to several outbreaks of tularemia, introduction of B. suis biovar 2 to western Europe, and subsequent encroachment of this brucellosis strain into the wild boar population of western Europe (19). During 1993–2003, B. suis biovar 2 infections were reported in >40 outdoor-rearing pig farms in France (<u>19</u>). Illegal trade can also be a possible source of human infection. In March 1994, psittacosis developed in A psittacosis outbreak in customs officers in Antwerp (Belgium). [Bull Inst Marit Trop Med Gdynia. 1998] several customs officers in Antwerp, Belgium (23). A customs officer had been hospitalized with Highly pathogenic H5N1 influenza virus in smuggled Thai pneumonia 10 days after exposure to parakeets illegally imported by an Indian sailor. The risk of eagles, Belgium. [Emerg Infect Dis. 2005] contracting psittacosis was 2.8× higher for officers exposed to parakeets >2 hours than for those exposed only briefly. Similarly, a highly pathogenic avian influenza A H5N1 virus from crested hawk eagles smuggled into Europe by air travel has been isolated and characterized (24); fortunately, however, screening of human and avian contacts indicated that no dissemination had occurred. Emerg Infact Bushmeat, Wet Markets, Exotic Foods, and Zoonotic Diseases Go to: ₩ Another risk factor related to the emergence of zoonotic diseases from wildlife has been the considerable Wildlife trade and global disease emergence. <u>\_</u> [Emerg Infect Dis. 2005] increase in consumption of bushmeat in many parts of the world, especially Central Africa and the Amazon Emergence of unique primate T-lymphotropic viruses among Basin, where 1–3.4 million tons and 67–164 million kilograms, respectively, are consumed each year (Z). central African bushmeat hunte [Proc Natl Acad Sci U S A. 2005] The simian foamy virus has been identified as a zoonotic retrovirus that infects people who have direct Isolation and phylogenetic characterization of Ebola viruses contact with fresh nonhuman primate bushmeat; this finding indicates that such zoonoses are more causing different outbreaks in Gabon. [Emerg Infect Dis. 1997] frequent, widespread, and contemporary than previously appreciated. Similarly, new retroviruses, human T-lymphotropic virus types 3 and 4 were found in persons who hunt, butcher, or keep monkeys or apes as pets in southern Cameroon (25). The combination of urban demand for bushmeat (a multibillion-dollar business) and greater access to primate habitats provided by logging roads has increased the amount of hunting in Africa, which has increased the frequency of human exposure to primate retroviruses and other disease-causing agents. Similarly, several outbreaks of Ebola virus in western Africa have been associated with consumption of bushmeat, mainly chimpanzees that were found dead (26). Traditional and local food markets in many parts of the world can be associated with emergence of new Transmission of avian influenza viruses to and between Emerg Infact [J Infect Dis. 2005] humans. zoonotic diseases. Live animal markets, also known as wet markets, have always been the principal mode Review Conservation medicine and a new agenda for of commercialization of poultry and many other animal species. Such markets, quite uncommon in the emerging diseases. [Ann N Y Acad Sci. 2004] United States and, until recently, in California, are emerging as a new mode of commercialization within Bats are natural reservoirs of SARS-like coronaviruses. specific ethnic groups for whom this type of trade assures freshness of the product but raises major public [Science. 2005] health concerns. The avian influenza epidemic, which began in Southeast Asia in 2003 and recently spread Complete or near-complete nucleotide sequences of hepatitis E to other parts of the world, is directly related to infected birds sold live in traditional markets. Live bird virus genome recovered from a wild boar, a deei [Virology. 2004] markets facilitate the spread of this avian H5N1 virus by wild birds (27). Similarly, the newly discovered severe acute respiratory syndrome-associated coronavirus was linked to trade of live, wild carnivores, especially civets, in the People's Republic of China (2). However, recent data suggest that civets may be only amplifiers of a natural cycle involving trade and consumption of bats (28). Trichinellosis has long been associated with consumption of undercooked meat from wild animals, such as bears, and now consumption of uncooked meat from deer and wild boar has recently been associated with emergence of severe cases of hepatitis E in hunters in Japan (29). Industrialized nations' new taste for exotic food has also been linked with various zoonotic pathogens or parasites, such as protozoa (Toxoplasma), trematodes (Fasciola sp., Paragonimus spp.), cestodes (Taenia spp., Diphyllobothrium sp.), and nematodes (Trichinella spp., Anisakis sp., Parastrongylus spp.). **Ecotourism** Go to: ₩ Adventure travel is the largest growing segment of the leisure travel industry; growth rate has been 10% Review Rickettsioses and the international traveler. [Clin Infect Dis. 2004] per year since 1985 (Adventure Travel Society, pers. comm.). This type of travel increases the risk that tourists participating in activities such as safaris, tours, adventure sports, and extreme travel will contact pathogens uncommon in industrialized countries. The most commonly encountered rickettsial infection in travel medicine is African tick bite fever, caused by *Rickettsia africae* and transmitted in rural sub-Saharan Africa by ungulate ticks of the *Amblyomma* genus; >350 imported cases have been reported from several continents during the past few years (30). Most patients are infected during wild game safaris and bush walks. Moreover, because ecotourism is becoming increasingly popular with international travelers, more cases of imported rickettsioses are likely to occur in Europe, North America, and elsewhere in years to come. Cercopithecine herpesvirus 1 (herpes B virus) is an alpha herpesvirus endemic to Asian macaques, which B-virus (Cercopithecine herpesvirus 1) infection in humans and macaques: potential for zoonotic diseas [Emerg Infect Dis. 2003] mostly carry this virus without overt signs of disease. However, zoonotic infection with herpes B virus in humans usually results in fatal encephalomyelitis or severe neurologic impairment (31). Herpes B virus has Emerg Infact Dis been implicated as the cause of ≈40 cases of meningoencephalitis in persons who had direct or indirect contact with laboratory macaques. A survey of workers at a Balinese Hindu temple, a major tourist attraction where macaques roam free, showed that contact sufficient to transmit B virus occurred commonly between humans and macaques. Furthermore, 31 (81.6%) of 38 macaques at that location had antibodies to herpes B virus (31). Petting Zoos and Exotic Pets Go to: ₩ Petting zoos, where children are allowed to approach and feed captive wildlife and domestic animals, have Review Reports of zoonotic disease outbreaks associated with animal exhibits and availability of re [J Am Vet Med Assoc. 2004] been linked to several zoonotic outbreaks, including infections caused by Escherichia coli O157:H7, An outbreak of salmonellosis among children attending a reptile salmonellae, and Coxiella burnetii (32). More than 25 outbreaks of human infectious diseases associated exhibit at a zoo. [J Pediatr. 1998] with visitors to animal exhibits were identified during 1990–2000 (32). In an outbreak of salmonellosis at a Colorado zoo, 65 cases (most of them in children) were associated with touching a wooden barrier around the Komodo dragon exhibit. Salmonella organisms were isolated from 39 case-patients, a Komodo dragon, and the wooden barrier. Children who did not become infected were more likely to have washed their hands after visiting the exhibit (<u>33</u>). Emary Infect Dia Exposure to captive wild animals at circuses or zoos can also be a source of zoonotic infection. Twelve Mycobacterium tuberculosis infection as a zoonotic disease: transmission between humans and eler [Emerg Infect Dis. 1998] circus elephant handlers at an exotic animal farm in Illinois were infected with M. tuberculosis, and 1 had Epizootic of Mycobacterium bovis in a zoologic park. signs consistent with active disease after 3 elephants died of tuberculosis. Medical history and testing of [J Am Vet Med Assoc. 1995] the handlers indicated that the elephants had been a probable source of exposure for most of the infected persons (34). After an M. bovis outbreak in rhinoceroses and monkeys at a zoo in Louisiana, 7 animal handlers, previously negative for tuberculosis, had positive test results (35). Exotic pets are also a source of several human infections that vary from severe monkeypox related to pet Update: multistate outbreak of monkeypox--Illinois, Indiana, Kansas, Missouri, Ohio, a [MMWR Morb Mortal Wkly Rep. 2003] prairie dogs or lyssaviruses in pet bats to less severe but more common ringworm infections acquired from First reported prairie dog-to-human tularemia transmission, African pygmy hedgehogs or chinchillas. Epidemiologic and animal trace-back investigations confirmed Texas, 2002. [Emerg Infect Dis. 2004] that the first community-acquired cases of monkeypox in humans in the United States (71 cases) resulted Review Hedgehog zoonoses. from contact with infected prairie dogs that had been housed or transported with African rodents imported [Emerg Infect Dis. 2005] from Ghana (3). Similarly, an outbreak caused by Francisella tularensis type B occurred among wild-Prevalence of fecal shedding of Salmonella organisms among caught, commercially traded prairie dogs; F. tularensis antibodies in 1 exposed person documented the first captive green iguanas and potentia [J Am Vet Med Assoc. 1998] evidence of tularemia transmission from prairie dog to human (36). African pygmy hedgehogs have been implicated in human salmonellosis cases in the United States and Canada (37). In the United States, the number of commercialized reptiles, especially iguanas, imported per year has increased considerably to ≈1 million. The number of human cases of salmonellosis, especially in very young children, increased dramatically in parallel with iguana pet ownership. The Centers for Disease Control and Prevention estimates that ≈7% of human infections with salmonellae in the United States are associated with having handled a reptile. Most iguanas have a stable mixture of Salmonella serotypes in their intestinal tract and intermittently or continuously shed Salmonella organisms in their feces (38). Eight cases of rabies caused by a new rabies virus variant were reported in the state of Ceará, Brazil, from Rabies in marmosets (Callithrix jacchus), Ceará, Brazil. [Emerg Infect Dis. 2001] 1991 through 1998. Marmosets (Callithrix jacchus jacchus) were determined to be the source of exposure. These primates are common pets; most cases occurred in persons who had tried to capture them, and 1 case was transmitted by a pet marmoset (39). In 1999, encephalitis was diagnosed in an Egyptian rousette bat (Rousettus egyptiacus) that had been imported from Belgium and sold in a pet shop in southwestern France. The pet bat was infected with a Lagos bat lyssavirus and resulted in the treatment of 120 exposed persons (Y. Rotivel, pers. comm.). Conclusion Go to: ₩ Emerging infectious diseases have a major effect on human health and can create tremendous economic Public health. Pathogen surveillance in animals. [Science. 2005] losses. Animals, particularly wild animals, are thought to be the source of >70% of all emerging infections Bushmeat hunting, deforestation, and prediction of zoonoses (40). Leading factors for emergence of zoonoses are unbalanced and selective forest exploitation and [Emerg Infect Dis. 2005] emergence. aggressive agricultural development associated with an exponential increase in the bushmeat trade ( $\delta$ ). Similarly, the increase of ecotourism, often in primitive settings with limited hygiene, can be associated with the acquisition of zoonotic agents. Therefore, development of appropriate programs for surveillance and for monitoring emerging diseases in their wildlife reservoirs is essential. Most animal pathogens for which surveillance programs exist relate to farm animals, and few or no programs are specifically aimed at wildlife. Two different but complementary approaches are 1) to monitor the presence of specifically identified pathogens that have emerged as human pathogens and 2) to investigate in a given wildlife species the presence of known or unknown infectious agents. Furthermore, conservation of habitat biodiversity is critical for preventing emergence of new reservoirs or amplifier species. Key measures for reducing the dispersion of emerging zoonoses include sustainable agricultural development, proper education of tourists about the risks of outdoor activities, and better control of the live animal trade (exotic pets, wet markets, bushmeat). Public health services and clinical practitioners (physicians, veterinarians) need to more actively educate the public about the risks of owning exotic pets and adopting wild animals. Emerg Infact As suggested by Kuiken et al. (40), it is time to form "a joint expert working group to design and Public health. Pathogen surveillance in animals. [Science. 2005] implement a global animal surveillance system for zoonotic pathogens that gives early warning of pathogen emergence, is closely integrated to public health surveillance and provides opportunities to control such pathogens before they can affect human health, food supply, economics or biodiversity." Major tasks that should be taken by the international community include better integration and coordination of national surveillance systems in industrialized and developing countries; improved reporting systems and international sharing of information; active surveillance at the interface of rural populations and wildlife habitats, especially where poverty and low income increase risks for pathogen transmission; training of professionals, such as veterinarians and biologists, in wildlife health management; and establishment of collaborative multidisciplinary teams ready to intervene when outbreaks occur. Go to: ₩ Biography • Dr Chomel is director of the World Health Organization/Pan American Health Organization Collaborating Center on New and Emerging Zoonoses at the University of California, Davis. His research Emerg Infact Dis focuses on zoonotic infections, especially Bartonella spp., in domestic animals and wildlife and their effects on human health. **Footnotes** Go to: ₩ <sup>1</sup>Presented at the International Symposium on Emerging Zoonoses, March 22–24, 2006, Atlanta, Georgia, USA. Suggested citation for this article: Chomel BB, Belotto A, Meslin F-X. Wildlife, exotic pets, and emerging zoonoses. Emerg Infect Dis [serial on the Internet]. 2007 Jan [date cited]. http://www.cdc.gov/ncidod/EID/13/1/6.htm References Go to: 💟 1. Taylor LH, Latham SM, Woolhouse ME Risk factors for human disease emergence. Philos Trans R Soc Lond B Biol Sci 2001;356:983–9 10.1098/rstb.2001.0975 [PMC free article] [PubMed] [CrossRef] Google Scholar 2. Daszak P, Tabor GM, Kilpatrick AM, Epstein J, Plowright R Conservation medicine and a new agenda for emerging diseases. Ann N Y Acad Sci 2004;1026:1–11 10.1196/annals.1307.001 [PubMed] [CrossRef] [Google Scholar] 3. Centers for Disease Control and Prevention Update: multistate outbreak of monkeypox—Illinois, Indiana, Kansas, Missouri, Ohio, and Wisconsin, 2003. MMWR Morb Mortal Wkly Rep 2003;52:642-6 [PubMed] [Google Scholar] 4. Blancou J, Chomel BB, Belotto A, Meslin FX Emerging or re-emerging bacterial zoonoses: factors of emergence, surveillance and control. Vet Res 2005;36:507–22 10.1051/vetres:2005008 [PubMed] [CrossRef] [Google Scholar] 5. Cleaveland S, Laurenson MK, Taylor LH Diseases of humans and their domestic mammals: pathogen characteristics, host range and the risk of emergence. Philos Trans R Soc Lond B Biol Sci 2001;356:991-9 10.1098/rstb.2001.0889 [PMC free article] [PubMed] [CrossRef] [Google Scholar] 6. Chardonnet P, des Clers B, Fischer J, Gerhold R, Jori F, Lamarque F The value of wildlife. Rev Sci Tech 2002;21:15–51 [PubMed] [Google Scholar] 7. Karesh WB, Cook RA, Bennett EL, Newcomb J Wildlife trade and global disease emergence. Emerg Infect Dis 2005;11:1000–2 [PMC\_free\_article] [PubMed] [Google\_Scholar] 8. Wolfe ND, Daszak P, Kilpatrick AM, Burke DS Bushmeat hunting, deforestation, and prediction of zoonoses emergence. Emerg Infect Dis 2005;11:1822-7 [PMC\_free\_article] [PubMed] [Google\_Scholar] 9. Schneider MC, Belotto A, Ade MP, Leanes LF, Correa E, Tamayo H, et al. Epidemiologic situation of human rabies in Latin America in 2004. Epidemiol Bull 2005;26:2-4 [PubMed] [Google Scholar] 10. Varma MGR Kyasanur Forest disease. In: Service MW, editor. The encyclopedia of arthropodtransmitted infections. New York: CABI Publishing; 2001. p. 254-60. [Google Scholar] 11. Walker DH, Barbour AG, Oliver JH, Lane RS, Dumler JS, Dennis DT, et al. Emerging bacterial zoonotic and vector-borne diseases. Ecological and epidemiological factors. JAMA 1996;275:463-9 10.1001/jama.275.6.463 [PubMed] [CrossRef] [Google Scholar] 12. Nettles VF Wildlife diseases and population medicine. J Am Vet Med Assoc 1992;200:648–52 [PubMed] [Google Scholar] 13. Alexander KA, Pleydell E, Williams MC, Lane EP, Nyange JF, Michel AL Mycobacterium Emary Infect Dia tuberculosis: an emerging disease of free-ranging wildlife. Emerg Infect Dis 2002;8:598-601 [PMC free article] [PubMed] [Google Scholar] 14. Charrel RN, de Lamballerie X Arenaviruses other than Lassa virus. Antiviral Res 2003;57:89–100 10.1016/S0166-3542(02)00202-4 [PubMed] [CrossRef] [Google Scholar] 15. Hubschle OJ Rabies in the kudu antelope (Tragelaphus strepsiceros). Rev Infect Dis 1988;10(Suppl 4):S629–33 [PubMed] [Google Scholar] 16. Daszak P, Cunningham AA, Hyatt AD Anthropogenic environmental change and the emergence of infectious diseases in wildlife. Acta Trop 2001;78:103-16 10.1016/S0001-706X(00)00179-0 [PubMed] [CrossRef] [Google Scholar] 17. Wilson PR Advances in health and welfare of farmed deer in New Zealand. N Z Vet J 2002;50(Suppl):105–9 [PubMed] [Google Scholar] 18. Sharp D Bovine tuberculosis and badger blame. Lancet 2006;367:631-3 10.1016/S0140-6736(06)68240-8 [PubMed] [CrossRef] [Google Scholar] Emarg Infact Dis 19. Godfroid J, Cloeckaert A, Liautard JP, Kohler S, Fretin D, Walravens K, et al. From the discovery of the Malta fever's agent to the discovery of a marine mammal reservoir, brucellosis has continuously been a reemerging zoonosis. Vet Res 2005;36:313–26 10.1051/vetres:2005003 [PubMed] [CrossRef] [Google Scholar] 20. Check E Health concerns prompt US review of exotic-pet trade. Nature 2004;427:277. [PMC free article] [PubMed] [Google Scholar] 21. Woodford MH, Rossiter PB Disease risks associated with wildlife translocation projects. Rev Sci Tech 1993;12:115–35 [PubMed] [Google Scholar] 22. Gylys L, Chomel BB, Gardner IA Epidemiological surveillance of rabies in Lithuania from 1986 to 1996. Rev Sci Tech 1998;17:691–8 [PubMed] [Google Scholar] 23. De Schrijver K A psittacosis outbreak in customs officers in Antwerp (Belgium). Bull Inst Marit Trop Med Gdynia 1998;49:97–9 [PubMed] [Google\_Scholar] 24. Van Borm S, Thomas I, Hanquet G, Lambrecht B, Boschmans M, Dupont G, et al. Highly pathogenic H5N1 influenza virus in smuggled Thai eagles, Belgium. Emerg Infect Dis 2005;11:702-5 [PMC\_free\_article] [PubMed] [Google\_Scholar] Intert Dis 25. Wolfe ND, Heneine W, Carr JK, Garcia AD, Shanmugam V, Tamoufe U, et al. Emergence of unique primate T-lymphotropic viruses among central African bushmeat hunters. Proc Natl Acad Sci U S A 2005;102:7994–9 10.1073/pnas.0501734102 [PMC\_free\_article] [PubMed] [CrossRef] [Google\_Scholar] 26. Georges-Courbot MC, Sanchez A, Lu CY, Baize S, Leroy E, Lansout-Soukate J, et al. Isolation and phylogenetic characterization of Ebola viruses causing different outbreaks in Gabon. Emerg Infect Dis 1997;3:59–62 [PMC\_free\_article] [PubMed] [Google\_Scholar] 27. Hayden F, Croisier A Transmission of avian influenza viruses to and between humans. J Infect Dis 2005;192:1311–4 10.1086/444399 [PMC free article] [PubMed] [CrossRef] [Google Scholar] 28. Li W, Shi Z, Yu M, Ren W, Smith C, Epstein JH, et al. Bats are natural reservoirs of SARS-like coronaviruses. Science 2005;310:676–9 10.1126/science.1118391 [PubMed] [CrossRef] [Google Scholar] 29. Takahashi K, Kitajima N, Abe N, Mishiro S Complete or near-complete nucleotide sequences of hepatitis E virus genome recovered from a wild boar, a deer, and four patients who ate the deer. Virology 2004;330:501–5 10.1016/j.virol.2004.10.006 [PubMed] [CrossRef] [Google Scholar] 30. Jensenius M, Fournier PE, Raoult D Rickettsioses and the international traveler. Clin Infect Dis 2004;39:1493-9 10.1086/425365 [PubMed] [CrossRef] [Google Scholar] 31. Huff JL, Barry PA B-virus (Cercopithecine herpesvirus 1) infection in humans and macaques: potential for zoonotic disease. Emerg Infect Dis 2003;9:246–50 [PMC free article] [PubMed] [Google Scholar] 32. Bender JB, Shulman SA Reports of zoonotic disease outbreaks associated with animal exhibits and availability of recommendations for preventing zoonotic disease transmission from animals to people in such settings. J Am Vet Med Assoc 2004;224:1105–9 10.2460/javma.2004.224.1105 [PubMed] [CrossRef] [Google Scholar] 33. Friedman CR, Torigian C, Shillam PJ, Hoffman RE, Heltzel D, Beebe JL, et al. An outbreak of salmonellosis among children attending a reptile exhibit at a zoo. J Pediatr 1998;132:802-7 10.1016/S0022-3476(98)70307-5 [PubMed] [CrossRef] [Google Scholar] 34. Michalak K, Austin C, Diesel S, Bacon MJ, Zimmerman P, Maslow JN Mycobacterium tuberculosis infection as a zoonotic disease: transmission between humans and elephants. Emerg Infect Dis 1998;4:283–7 [PMC free article] [PubMed] [Google Scholar] 35. Stetter MD, Mikota SK, Gutter AF, Monterroso ER, Dalovisio JR, Degraw C, et al. Epizootic of Mycobacterium bovis in a zoologic park. J Am Vet Med Assoc 1995;207:1618–21 [PubMed] [Google Scholar] 36. Avashia SB, Petersen JM, Lindley CM, Schriefer ME, Gage KL, Cetron M, et al. First reported prairie dog-to-human tularemia transmission, Texas, 2002. Emerg Infect Dis 2004;10:483–6 [PMC free article] [PubMed] [Google Scholar] 37. Riley PY, Chomel BB Hedgehog zoonoses. Emerg Infect Dis 2005;11:1–5 [PMC free article] [PubMed] [Google Scholar] 38. Burnham BR, Atchley DH, DeFusco RP, Ferris KE, Zicarelli JC, Lee JH, et al. Prevalence of fecal shedding of Salmonella organisms among captive green iguanas and potential public health implications. J Am Vet Med Assoc 1998;213:48–50 [PubMed] [Google Scholar] 39. Favoretto SR, de Mattos CC, Morais NB, Alves Araujo FA, de Mattos CA Rabies in marmosets Emary Infact Dia (Callithrix jacchus), Ceará, Brazil. Emerg Infect Dis 2001;7:1062–5 [PMC\_free\_article] [PubMed] Google Scholar 40. Kuiken T, Leighton FA, Fouchier RA, LeDuc JW, Peiris JS, Schudel A, et al. Public health: pathogen surveillance in animals. Science 2005;309:1680–1 10.1126/science.1113310 [PubMed] [CrossRef] [Google Scholar] Articles from Emerging Infectious Diseases are provided here courtesy of Centers for Disease Control and **Prevention** National Center for Biotechnology Information, U.S. National Library of Medicine Support Center 8600 Rockville Pike, Bethesda MD, 20894 USA Policies and Guidelines | Contact