

Most of the viral human infections and diseases which have emerged over the past 25 years have zoonotic transmissions as their origin (Table 1). Almost three-quarters of zoonotic transmissions are caused by pathogens of wildlife origin, mainly in the areas of sub-Saharan Africa, India and China, and to a lesser extent in North America and Europe (Fig. 1), and viruses comprise approximately 20% of all emerging infections. Zoonotic transmission is favoured by close contact between humans and animals, and insect vectors may be involved (Table 1).

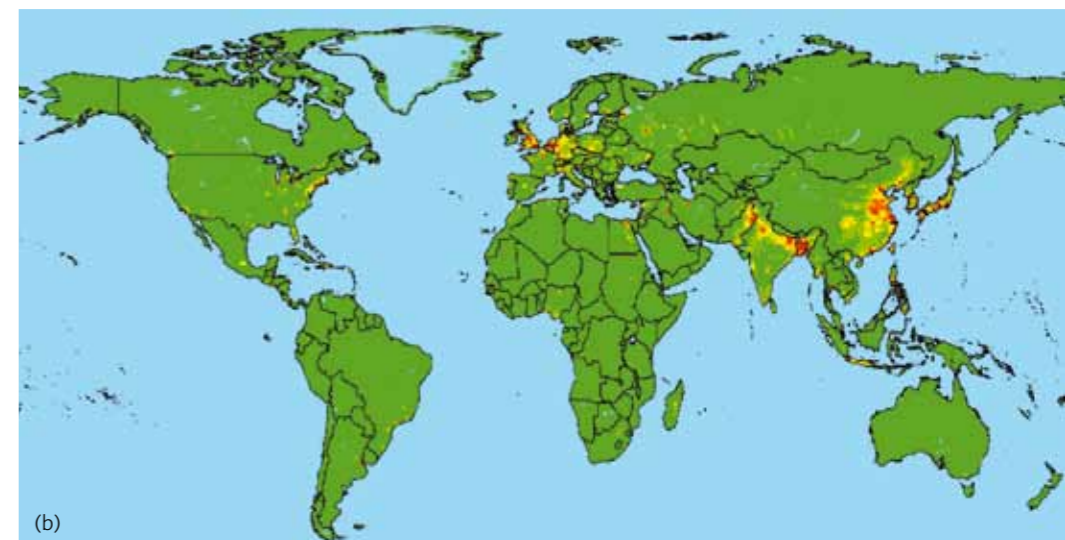
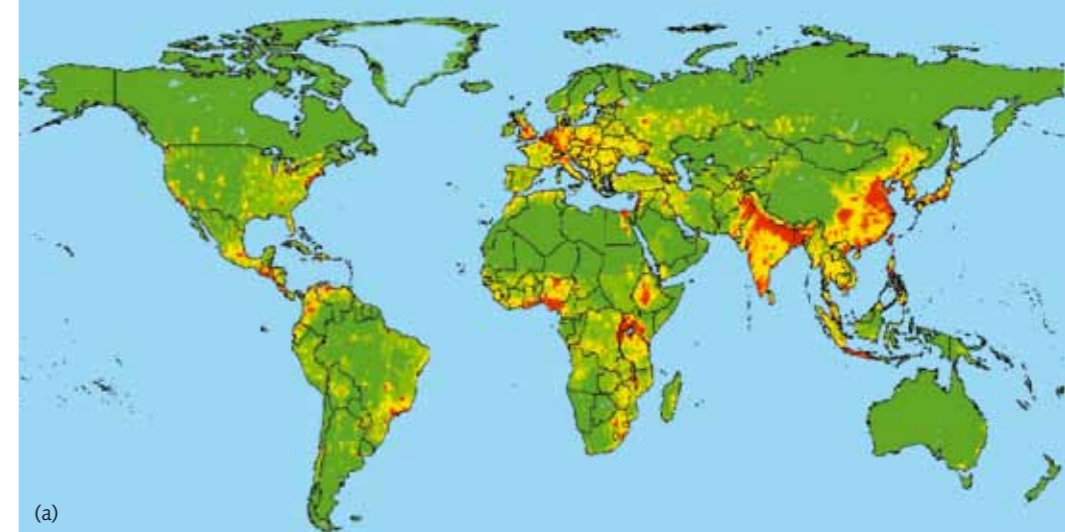
### Influenza

Influenza viruses of several human pandemics have been recognized as reassortants containing several genes from animal influenza viruses or as complete animal viruses. The 1957 H2N2 influenza virus ('Asian 'flu') and the 1968 H3N2 influenza virus ('Hong Kong 'flu') have picked up the viral haemagglutinin (HA) and several other genes from avian influenza viruses. On the other hand, analysis of the recently reconstructed H1N1 influenza virus that caused the 1918 pandemic ('Spanish 'flu') strongly suggested that it was an avian influenza virus which had been transmitted directly to humans. Similarly, the H5N1 influenza viruses causing small 'flu outbreaks in humans in Asia and Europe since 1997 are also completely of avian origin, most likely affecting people who raise and sell domestic birds for a living (Figs 2, 3).

The 2009 swine origin influenza A H1N1 virus (S-OIV) is itself a triple reassortant, arising from decades of circulation in pigs. Starting in Mexico, this virus spread to the US and Canada, then to Europe and elsewhere in 2009, and has now been declared the cause of a new pandemic by the World Health Organization (WHO).

# The significance of zoonotic transmission of viruses in human disease

Since the early days of modern virology animals have been recognized as real or potential reservoirs of viruses which can be transmitted to humans, as **Ulrich Desselberger** describes.



▲ Fig. 1. Global distribution of relative risk of an emerging infectious disease event caused by (a) zoonotic pathogens from wildlife, (b) zoonotic pathogens from non-wildlife. The linear scale ranges from green (lowest risk) via yellow to red (highest risk). Adapted with permission of Macmillan Publishing Ltd from Jones, K.E. et al., *Nature* (2008), 451, 990–994.

► Fig. 2. Health authority workers attempting to prevent the spread of an avian 'flu outbreak in China. Mike Clarke, AFP / Getty Images



◀ Fig. 3. Poultry markets in China. Peter Parks, AFP / Getty Images (left); China Photos / Getty Images (right)

Table 1. Confirmed or probable zoonotic transmissions of viruses to humans

Year	Virus	Disease	Species	Transmission pathway	References
1918	Influenza A virus	Spanish 'flu	Birds?	Direct transmission of an avian influenza virus	Stevens <i>et al.</i> , <i>Science</i> 2004, 303, 1866–1870
1957	Influenza A virus	Asian 'flu	Birds	Reassortment with avian influenza virus	Scholtissek <i>et al.</i> , <i>Virology</i> 1978, 87, 13–20
1968	Influenza A virus	Hong Kong 'flu	Birds	Reassortment with avian influenza virus	Scholtissek <i>et al.</i> , <i>Virology</i> 1978, 87, 13–20
1997	Influenza A virus	Avian 'flu	Goose?	Close contact in Hong Kong	Claas <i>et al.</i> , <i>Lancet</i> 1998, 351, 472–477
2009	Influenza A virus	Swine 'flu	Swine	Close contact with animals in Mexico?	Shinde <i>et al.</i> , <i>N Engl J Med</i> 2009, 360, 2616–2625; Zimmer & Burke, <i>N Engl J Med</i> 2009, 361, 279–285
1931?	HIV-1	AIDS	Chimpanzee	Close contact, use as food	Gao <i>et al.</i> , <i>Nature</i> 1999, 397, 436–441
1940?	HIV-2	AIDS	Sooty mangabey	Close contact	Chen <i>et al.</i> , <i>J Virol</i> 1997, 71, 3953–3960
1976ff	Hantavirus a.o.	Haemorrhagic fever with renal syndrome (HFRS)	Rodents	Close contact with rodent excretions (aerosols)	Lee & van der Groen, <i>Prog Med Virol</i> 1989, 36, 62–102
1993	Sin nombre virus (Bunyavirus)	Hantavirus pulmonary syndrome	Rodents	Close contact with rodent excretions (aerosols)	Nichol <i>et al.</i> , <i>Science</i> 1993, 262, 914–917
1993ff	Rotavirus group A	Acute gastroenteritis	Cats, piglets, calves, rabbits	Close contact with animals	Das <i>et al.</i> , <i>Virology</i> 1993, 194, 374–379; Matthijssens <i>et al.</i> , <i>J Virol</i> 2006, 80, 3801–3810; Steyer <i>et al.</i> , <i>J Gen Virol</i> 2008, 89, 1690–1698
1994	Hendra virus (Paramyxovirus)	Acute respiratory distress syndrome; encephalitis	Fruit bats, horses	Close contact with horses	Murray <i>et al.</i> , <i>Science</i> 1995, 268, 94–97
1999	Nipah virus (Paramyxovirus)	Severe respiratory disease; encephalitis	Fruit bats, pigs	Close contact with pigs	Chua <i>et al.</i> , <i>Lancet</i> 1999, 354, 1257–1259
1999	West Nile Virus (Flavivirus)	Fever; encephalitis	Crows, horses	Close contact with animals; transmission by mosquitoes	Lanciotti <i>et al.</i> , <i>Science</i> 1999, 286, 2333–2337
2002	SARS coronavirus	Severe acute respiratory distress syndrome	Palm civets?	Originating in China Close contact with animals?	Ksiazek <i>et al.</i> , <i>N Engl J Med</i> 2003, 348, 1953–1966; Drosten <i>et al.</i> , <i>N Engl J Med</i> 2003, 348, 1967–1976; Peiris <i>et al.</i> , <i>Lancet</i> 2003, 361, 1319–1325; Kan <i>et al.</i> , <i>J Virol</i> 2005, 79, 11892–11900

## HIV

HIV-1 and HIV-2 (human immunodeficiency virus), members of the subfamily *Lentivirinae* of the *Retroviridae*, and the causative agents of AIDS, have been recognized as having originated from African monkeys: HIV-1 is closely related to the simian immunodeficiency virus of chimpanzees (SIVcpz), and HIV-2 to the SIV of sooty mangabeys (SIVsm).

## Other viruses

Since 1976, Hantaviruses (of the family *Bunyaviridae*) have been recognized as being causally associated with outbreaks of haemorrhagic fever with renal syndrome (HFRS), a disease particularly prevalent among military personnel since the First World War. These viruses are endemic in rodents and voles, and are mainly transmitted by aerosols of rodent excreta.

In 1993, a severe pulmonary syndrome occurred in several south-western states of the US ('four border disease'), caused by zoonotic transmission of another Bunyavirus, Sin nombre virus, which is endemic in rodents and co-evolves with them.

During the late 1990s, Hendra and Nipah viruses, both viruses of the *Paramyxoviridae* family, were transmitted from fruit bats to horses, pigs and humans. The SARS coronavirus, producing severe respiratory disease in humans in 2003, is likely to have been transmitted from palm civets and spread from south-east Asia to Canada and Europe.

West Nile virus, affecting crows and horses, was transmitted by insect vectors to humans and caused outbreaks of febrile encephalitis in the USA since 1999. In 1999, an outbreak of human encephalitis occurred in the eastern USA which was also due to infection with West Nile virus, transmitted by mosquitoes from *Corvus* (crow) species where it circulates naturally.

Group A rotaviruses of animal origin have been recognized in rotaviruses isolated from children with acute gastroenteritis as donors of individual genome segments after

reassortment events, or as whole animal viruses transmitted to humans.

## Surveillance

The above are only the most prominent examples of transmission of whole animal viruses or of parts of their genomes to humans. Many other cases of such transmission events have been reported in the literature. The issue is big enough to expand the epidemiological surveillance of human viral pathogens to that of animal viruses which have been proven or have the potential to be transmitted to humans. Indeed, such surveillance programmes are increasingly recognized as being worth the effort, and have been established for major pathogens like retroviruses and influenza viruses (for example: [www.defra.gov.uk/animalh/diseases/notifiable/ai/wildbirds/survey.htm](http://www.defra.gov.uk/animalh/diseases/notifiable/ai/wildbirds/survey.htm) and [www.defra.gov.uk/animalh/diseases/notifiable/ai/keptbirds/index.htm](http://www.defra.gov.uk/animalh/diseases/notifiable/ai/keptbirds/index.htm)).

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