

SARS legacy: outbreak reporting is expected and respected

On March 15, 2003, WHO declared that the new disease it called severe acute respiratory syndrome (SARS) was a worldwide health threat. The disease emerged in late 2002, when an outbreak of atypical pneumonia began in Guangdong Province, China. It subsequently spread across the world via major air routes, reaching 29 countries on five continents. This international spread began when a doctor who had treated patients in China arrived in Hong Kong on Feb 21, 2003. His 1-day stay in a hotel led to infection of 15 others who carried the infection to hospitals within Hong Kong and in Vietnam, Canada, Singapore, the USA, the Philippines, and Australia. This rapid international spread prompted WHO to issue the first global alert on March 12. 3 days later, a Singaporean doctor who had treated some of the first patients in Singapore developed symptoms while attending a medical conference in New York, USA. During his return journey, he was quarantined and admitted to hospital in Frankfurt, Germany. The causative agent was unknown at that time.¹

SARS was the first severe and readily transmissible new disease to emerge in the 21st century. Three factors led to intense discussions between senior WHO epidemiologists and the agency's Director-General: that the disease had emerged in southern China, an area from which many epidemiologists expected the next influenza pandemic to originate; that it caused outbreaks of a severe unidentified atypical pneumonia with respiratory failure within Asia and was spreading to North America and Europe; and finally that hospital workers particularly seemed to be at risk. But questions of the unknown dominated the discussions, not these facts. Was the syndrome caused by an infectious agent? If it was infectious, would it spread from health workers to their families and communities, or had it already done so? Were there asymptomatic infections? Could it sustain transmission indefinitely, and could it become endemic in people or become enzootic in animals leading to a constant threat of re-emergence in human beings?

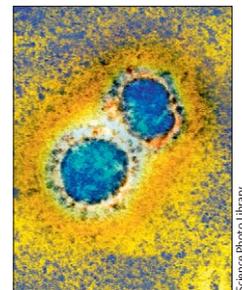
With the rapidity of spread by international air travel, WHO issued a rare travel advisory. This decision, made on March 15, 2003, is now public health history; WHO developed a case definition on the basis of existing evidence and the world was alerted again just 3 days

after the initial warning.² The unprecedented global solidarity that followed allowed early and real-time sharing of information and evidence by telephone, video, and the internet. The disease was spreading by face-to-face contact, probably through coughing and sneezing and possibly by fomites. Antivirals and antibiotics were not curative. Through a virtual network of laboratories coordinated by WHO with teleconferences and secure websites, the causative agent was identified as a novel coronavirus on March 22, 2003, and a diagnostic test was quickly developed.^{3,4}

Transmission outside China occurred in waves—from individuals initially infected in Hong Kong to hospital workers, from hospital workers to family members, and from family members to other close contacts in the community. For a respiratory disease, SARS was unusual in that transmission was low in the first 5 days of illness and peaked with increasing disease severity. This pattern of transmission allowed the disease to be contained by public health measures alone. However, the fact that transmissibility was greatest when illness was most severe contributed to the high proportion of secondary infections in health workers, who accounted for 1706 (21%) of 8096 cases reported.² The remaining infections occurred in chains of transmission from household and community contacts.²

The most notable and exceptional event was the outbreak in an apartment complex in Hong Kong, where more than 300 residents were infected, many without having had obvious face-to-face contact with each other. There was concern about a possible environmental factor in transmission.² Precautionary measures were applied, with WHO recommending that people postpone travel to Hong Kong and other areas where outbreaks were occurring and contact tracing was not linking cases. Airport arrivals in Hong Kong in May, 2003 fell by 68% and hotel occupancy by 78% compared with the same period 1 year earlier.⁵ Similar negative effects were also reported in Singapore, Vietnam, Taiwan, China, and elsewhere in Asia, contributing to an estimated short-term loss of US\$30 billion.

The international response to SARS was coordinated by WHO from its headquarters in Geneva, Switzerland, and from the Western Pacific Regional Office in Manila, Philippines, with the assistance of WHO country offices



Science Photo Library

See [Perspectives](#) page 797



Corbis

and from the Global Outbreak Alert and Response Network and its constituent partners.⁶ Ultimately, control of the course of the outbreak was the result of concerted multisectoral efforts, and by use of established tenets of disease control, such as safe infection-control practices in health-care settings, early case detection and isolation of patients, tracing and quarantining of SARS contacts, rapid dissemination of information, and raising of public awareness about risks.⁷

The new disease was transmitted from person to person for about 8 months and then disappeared after an unprecedented level of international cooperation and collaboration. By July 5, 2003, WHO was able to declare that “all known chains of person-to-person transmission of the SARS coronavirus” had been broken.⁷ Whether SARS would have become endemic in people or in an animal reservoir without this determined global health response will never be known. One clear lesson that emerged from the outbreak, however, was that inadequate surveillance and response capacity in one country can endanger not only its population, but also global public health security.⁸

As happened with smallpox—another disease that has disappeared from people—later cases did occur because of laboratory accidents. Additionally, investigation in the emergence of SARS identified small mammals sold for human consumption within live animal markets in Guangdong, China, as a milieu in which coronaviruses can be amplified and repeatedly cross the species barrier to human beings. Four cases of SARS were reported from Guangdong between December, 2003, and January, 2004; at least some patients were thought to have been to live animal markets.⁹ But the virus that had spread around the world earlier in 2003 seemed to have a mutation, with an important 29 base-pair deletion in *ORF8* that created a novel genetic sublineage.¹⁰ This deletion was absent in virus isolates from civets and in the later four human cases.¹⁰

Perhaps the most important legacy of the SARS outbreak resulted from the courage of the WHO Director-General, Gro Harlem Brundtland. Concerned about delays in official reporting and ineffective outbreak containment that led to the global outbreak, she publicly accused a WHO Member State of placing the world at risk.¹¹ Official reporting and effective national outbreak control followed, and, in what became perhaps the greatest legacy of SARS, disease reporting

changed almost overnight from being approached with hesitancy and preoccupation with concern about the potential economic fallout from such transparency, to something that was simply expected and respected. This development was enshrined in an international agreement after the World Health Assembly—concerned about the emergence and rapid spread of SARS—urged WHO to give high priority to the work on the revision of the International Health Regulations “using experiences, knowledge, and learning acquired during the SARS response”.¹² 4 years later, in 2007, the new International Health Regulations (IHR 2005)¹³ came into force and now provide the legal framework with which reporting and risk assessments for public health emergencies of international concern are required.

Now, countries are expected to report unusual and unexplained outbreaks of disease despite any potential economic effects, and reporting is respected internationally. The first cases of severe human pneumonia caused by influenza A (H5N1)—detected and reported in Vietnam and Thailand between late 2003, and early 2004—were probably identified partly because of enhanced alertness after the SARS outbreak, and led to the recognition and reporting of disease in poultry. Human infections with influenza A (H5N1) virus continue to be reported, despite severe and often uncompensated culling and decreased travel, trade, and tourism.

Reporting expectations were clearly demonstrated by the emergence of another novel coronavirus in Saudi Arabia in 2012. Under the framework of the IHR 2005, Saudi Arabia, Qatar, and Jordan—countries where people infected with this novel virus lived—worked together with other countries where patients had been admitted to hospital, such as the UK and Germany, and with a global network of laboratories and WHO to review the available evidence and assess and communicate the risk globally to help prevent an irrational response.¹⁴ New laboratory tests are being developed. Recent evidence of limited person-to-person transmission of this same novel coronavirus in the UK from an index case who seemed to have acquired the infection in the Middle East has heightened concern about the potential of this newly identified virus. WHO has communicated the urgency for enhanced and proactive surveillance of severe acute respiratory infections, and patients with severe pneumonia should be investigated with diagnostic tests, especially those with relevant travel

history. Both well and sick contacts of confirmed cases should also be intensively investigated.

As with several other viral infections (eg, Nipah and Hendra viruses), bats have been identified as the probable animal reservoir from which the SARS coronavirus originally emerged. This finding has led to additional research on viruses carried by bats and rodents; such information was useful when the novel coronavirus was first detected in 2012, because it is a close genetic relative of bat viruses.¹⁵ Indeed, investigations have shown that phylogenetically related viruses occur widely in some insectivorous bat species, indicating that these viruses originated in bats.¹⁶

Emerging infectious disease outbreaks all emphasise the need for collaboration between organisations responsible for human health, animal health, and the environment. The notion behind collaborative effects of several disciplines to attain the best possible health for people, animals, and the environment needs to gain more traction. The Food and Agriculture Organization, the World Health Organization for Animals, and WHO are sharing responsibilities and coordinating activities to assess risks at the interface between people, animals and the ecosystem, and providing leadership in this arena.¹⁷

The 10 years since SARS emerged have made a difference. The IHR 2005 enshrine the expectation that public health emergencies of international concern be reported and managed in a way that respects the countries that report promptly. Rapid and sensitive molecular diagnostic tests are being developed, deployed, and used. There is now an improved awareness of the importance of zoonotic threats from wildlife and domestic animals. Therefore, all countries can attain the ultimate goal of the IHR 2005: development of public health capacity to detect and respond to diseases when and where they occur.

In the late 1990s, WHO developed a vision for global health security as a world on the alert and ready to respond rapidly—both locally and globally—to threats from emerging infections. The SARS outbreak and the IHR 2005 have helped to move the world closer to this vision with a new mantra—one of expectation and respect. 10 years after SARS, how the global public health and animal health community responds to the newly

emerging coronavirus threat will be a test of what has been achieved and whether the one-health notion can move beyond words to practical action.

*David L Heymann, John S Mackenzie, Malik Peiris
Centre on Global Health Security, Chatham House, London, UK (DLH); Infectious Disease Epidemiology, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK (DLH); Tropical Infectious Diseases, Faculty of Health Sciences, Curtin University, Perth, WA, Australia (JSM); Burnet Institute, Melbourne, VIC, Australia (JSM); and Centre of Influenza Research, School of Public Health, The University of Hong Kong, Hong Kong Special Administrative Region, China (MP)
david.heyman@lshtm.ac.uk

We declare that we have no conflicts of interest.

- 1 Heymann DL. The international response to the outbreak of SARS in 2003. *Trans R Soc Lond B Biol Sci* 2004; **359**: 1127–29.
- 2 WHO Regional Office for the Western Pacific. SARS: how a global epidemic was stopped. Geneva: World Health Organization, 2006.
- 3 Peiris JSM, Lai ST, Poon LL, et al. Coronavirus as a possible cause of severe acute respiratory syndrome. *Lancet* 2003; **361**: 1319–25.
- 4 Stöhr K. A multicentre collaboration to investigate the cause of severe acute respiratory syndrome. *Lancet* 2003; **361**: 1730–33.
- 5 Wong YCR, Siu A. Counting the economic cost of SARS. In: Peiris M, Anderson LJ, Osterhaus ADME, Stöhr K, Yuen KY. Severe acute respiratory syndrome. Oxford: Blackwell Publishing, 2005: 213–30.
- 6 Mackenzie JS, Drury P, Ellis A et al. The WHO response to SARS, and preparations for the future. In Knobler S, Mahmoud A, Lemon S, Mack A, Sivitz L, Oberholtzer K. Learning from SARS: Preparing for the Next Disease Outbreak. Washington DC: Institute of Medicine, US National Academies, 2004: 42–50.
- 7 WHO. Global alert and response: severe acute respiratory syndrome (SARS). http://www.who.int/csr/don/archive/disease/severe_acute_respiratory_syndrome/en/index.html (accessed Jan 21, 2013).
- 8 Heymann DL, Rodier G. Global surveillance, national surveillance, and SARS. *Emerg Infect Dis* 2004; **10**: 173–75.
- 9 Liang G, Chen Q, Xu J, et al, for the SARS Diagnosis Working Group. Laboratory diagnosis of four recent sporadic cases of community-acquired SARS, Guangdong Province, China. *Emerg Infect Dis* 2004; **10**: 1774–81.
- 10 Guan Y, Zheng BJ, He YQ, et al. Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. *Science* 2003; **302**: 276–78.
- 11 Fleck F. How SARS changed the world in less than six months. *Bull World Health Organ* 2003; **81**: 625–26.
- 12 WHO. Severe acute respiratory syndrome (SARS). May 28, 2003. <http://www.who.int/csr/sars/en/ea56r29.pdf> (accessed Jan 21, 2013).
- 13 WHO. International Health Regulations (2005). 2008. <http://www.who.int/ihr/en/> (accessed Jan 21, 2013).
- 14 WHO. Background and summary of novel coronavirus infection—as of 30 November 2012. http://www.who.int/csr/disease/coronavirus_infections/update_20121130/en/index.html (accessed Jan 21, 2013).
- 15 Zaki AM, van Boheemen S, Bestebroer TM, Osterhaus AD, Fouchier RA. Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. *N Engl J Med* 2012; **367**: 1814–20.
- 16 Annan A, Baldwin HJ, Corman VM, et al. Human betacoronavirus 2c EMC/2012—related viruses in bats, Ghana and Europe. *Emerg Infect Dis* 2013; published online Feb 12. <http://dx.doi.org/10.3201/eid1903.121503>.
- 17 The FAO-OIE-WHO Collaboration. Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interface: a tripartite concept note. April, 2010. http://www.who.int/foodsafety/zoonoses/final_concept_note_Hanoi.pdf (accessed Jan 21, 2013).