Severe acute respiratory syndrome and biology, air quality, physics, and mechanical engineering

This commentary is based on the proceedings of two meetings co-hosted by Civic Exchange, the Hong Kong University of Science and Technology, and the Hong Kong Science Museum. The meetings were held on 31 May and 6 June 2003.

Introduction

The US Centers for Disease Control and Prevention state that the primary way that severe acute respiratory syndrome (SARS) appears to be spread is by close person-to-person contact, and contact with infectious droplets. They further state that it is also possible that SARS could be spread more broadly through the air, or by other means currently not known.[1] The possibility of non-droplet transmission as a means of spread has been voiced previously by Ronald Atlas, the President of the American Society of Microbiology. Commenting on the Metropole Hotel outbreak he stated this would suggest "that it spread through the air-conditioning system".[2] This was also echoed at two recent multi-disciplinary, local meetings where speakers were predominantly non-medical scientists from the Hong Kong University of Science and Technology (HKUST). Call was made not to neglect the possibility of the airborne mode of spread in future research on SARS transmission. Concern was raised regarding the current paradox of advocating improvement of indoor ventilation at medical facilities, which helps to control airborne infection, but not droplet spread.[3] This commentary, based largely on these non-medical scientists' perspectives on SARS, illustrates the abundance of local scientific expertise available and the eagerness of these scientists to assist in the understanding of the SARS outbreak.

Aerosol effect

Professor M Fang of HKUST explained that in terms of an aerosol effect, sneezing could have an ejection velocity of up to 100 km per hour. Roughly speaking, the number of droplets produced from coughing is about 40 000, talking 10 000, and singing 1000. Droplets vary in size from 50 microns to 3 microns, a cross-section of a human hair being approximately 50 microns as a comparison. Large droplets do not travel far. Droplets of 3 microns in size can stay in the air for 3 hours. The coronavirus is approximately 0.1 micron in size. The N95 mask filters 95% of particles with 0.1 micron in size, and the common surgical mask is equivalent to an N74. Experiments at the HKUST with flushing of the sitting toilet using fluorescent-stained water, showed significant contamination by droplets on the toilet seat, and an aerosol effect of up to the standing height of a child, but little aerosol effect of up to adult height. Under laboratory conditions, a good portion of these droplets are evaporated, suggesting they may become airborne or re-deposited within 25 seconds.

Chimney effect

Professor SC Kot of the HKUST described spread by the so-called chimney effect, which the World Health Organization have referred to as the "natural current" effect. Ordinarily, the chimney effect implies a temperature differential. However, in the case of the spread of the SARS epidemic at Amoy Gardens, airflow up the light well of Block E was caused by aerodynamics similar to that of an airplane wing's lifting power. This effect was clearly demonstrated on a video recording, using a model of the tower blocks inside a wind tunnel, with airflow direction made visible by the use of a smoke generator.

Indoor ventilation

Professor CYH Chao of the HKUST explained that special air-handling and ventilation approaches to management are only required if SARS transmission occurs by airborne means. Current advocacy for improved ventilation to contain the spread of SARS is therefore contradictory to the belief that SARS is transmitted primarily by direct contact and droplets. Droplets do not remain suspended in the air. Droplet transmission *must not* be confused with airborne transmission.[3] With respect to droplet transmission, ventilation and temperature control has a dilution effect. Ventilation control of airflow patterns is effective to control droplet spread, due to its directional nature.

Infrared temperature detectors

Professor LK Sou of the HKUST explained the basic limitations of infrared temperature detectors in current use. At Hong Kong's border with mainland China, rapid body temperature screening involves a spot-to-spot single reading. Only one reading from one spot of the subject is measured, but the cost is low at just several thousand Hong Kong dollars. With a more expensive infrared temperature detector, detection is based on focal-plane array detectors of 1024 x 1024 pixels, with imaging showing up regions of different temperature by pseudo-colours. This model costs several hundred times more than the single reading model, but reads far more information.

There are numerous factors that make accurate infrared temperature measurement difficult to achieve. These can include skin colour, wrinkled/shiny skin, dry/sweaty skin, recent exercise, emotional status, food habits, and differences by age-group, as well as constitutional differences.

Body temperature is also diurnal, being lowest at 2 to 4 am and highest at 4 to 6 pm. Despite these obstacles, Professor Sou advocated use of infrared temperature screening, which he viewed as erring on the side of caution and also acting as a form of deterrent.

Biology

Theoretically, being an RNA virus, mutation is likely, as polymerase-based replication is not checked for accuracy like that of DNA replication in eukaryotic cells. If rapid mutation does occur, it will make a useful vaccine or treatment more difficult to develop. Investigations to date have demonstrated no major variant in the genetic machinery of virus isolates from Canada, Hanoi, Hong Kong, Guangzhou, and Beijing.[4] It is possible that in the long term, the virus will mutate to become less virulent rather than more deadly, since it behooves a virus to keep its host alive.[5] However, Professor D Chang of HKUST suggested that this Darwinian assumption should also take the random nature of mutation into account, and that this could potentially make the virus even more virulent than at present.

Synergism of multidisciplinary scientific knowledge

Despite the current absence of proven, satisfactory medical treatment, SARS seems to have been rapidly contained. This may reflect a historically unparalleled use of knowledge-based weapons against disease—information technology, communications, and advances in molecular biology. An incredible rate of knowledge dissemination and a high level of collaboration has been possible via the Internet, and this has guided strategies to contain SARS.[6] Clinical science and medical knowledge alone was not sufficient to control disease spread. What was instead witnessed was an incredible synergism of scientific knowledge, of enormous impact for disease control.

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CYC Wong, MD, FHKAM (Paediatrics)
(e-mail: chuck@wongsworld.org)
Room 1301, Champion Building
301-309 Nathan Road
Kowloon, Hong Kong

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