Experience of Severe Acute Respiratory Syndrome in Singapore: Importation of Cases, and Defense Strategies at the Airport

Annelies Wilder-Smith, Kee Tai Goh and Nicholas I Paton

Background: The importation of SARS was responsible for the outbreaks in Singapore, Hong Kong, Vietnam and Canada at a time when this new disease had not been identified. We report the incidence and impact of cases of SARS imported to Singapore between 25 February and 31 May 2003, and describe national measures to prevent further importation.

Methods: Information on imported cases of SARS and measures taken at entry points to Singapore was retrieved from the Ministry of Health and the Civil Aviation Authority of Singapore.

Results: Of the 6 imported cases, which all occurred before screening measures were implemented at the airport, only the first resulted in extensive secondary transmission. Of 442,973 air passengers screened after measures were implemented, 136 were sent to a designated hospital for further SARS screening; none was diagnosed as having SARS.

Conclusions: The SARS outbreak in Singapore can be traced to the first imported case. The absence of transmission from the other imported cases was probably a result of relatively prompt identification and isolation of cases, together with a low potential for transmission. New imported SARS cases therefore need not lead to major outbreaks if systems are in place to identify and isolate them early. Screening at entry points is costly, has a low yield and is not sufficient in itself, but may be justified in light of the major economic, social and international impact which even a single imported SARS case may have.

Introduction

On 12 March 2003, the World Health Organization (WHO) issued a global alert on severe acute respiratory disease (SARS), a new emerging respiratory illness associated with significant morbidity and mortality.1 International travel was responsible for the rapid intercontinental spread of this disease, and by 31 May 2003 SARS had affected 32 countries with a total number of 8,360 cases. The large outbreaks in Hong Kong, Toronto, Singapore and Vietnam were initiated by cases that were imported before this new disease had been identified and before appropriate measures had been put in place to prevent transmission.2–4 There remains a concern that, even with such measures, prevention of transmission from imported SARS cases may be difficult for countries that receive many international travelers from areas badly affected by SARS.3 Singapore has one of the busiest airports in Southeast Asia, and has numerous arrivals each day from countries in the region affected by SARS. The country is therefore potentially vulnerable to importation of SARS cases that may initiate new outbreaks.

We report the incidence of imported cases of SARS to Singapore and its impact on the national SARS outbreak. We also describe the national response in preventing further importation of SARS.

Methods

Information was retrieved from the Singapore Ministry of Health on cases of imported SARS from the day on which the first cases of SARS arrived in Singapore (25 February) until 31 May 2003, when Singapore was declared SARS-free by the WHO. These cases were verified against hospital records. The WHO definition for probable SARS was used.
Information on measures taken at the national airport (Changi Airport), seaports and road entry points to reduce the importation of further cases was obtained from the Civil Aviation Authority of Singapore (CAAS) and from the websites of the Ministry of Health, Singapore (http://www.moh.gov.sg/sars/news/chronology.html; accessed 15 June).

**Results**

**Importation of Cases of SARS**

Seven imported cases were notified to the Ministry of Health between 14 March and 31 May 2003. One was excluded as imported SARS after review of the case notes: the subsequent clinical impression during the course of disease was not that of SARS, and convalescent SARS serologies remained negative. Of the 6 persons who imported SARS (confirmed by serology and/or SARS coronavirus polymerase chain reaction (PCR)) to Singapore, all were residents of Singapore and had visited Hong Kong (plus Guangdong in 2 cases and Beijing in 1 case).

Cases 1 and 2 traveled together to Hong Kong at the end of February 2003, and stayed on the 9th floor of Hotel M. They are likely to have been infected by a SARS patient (a Chinese doctor from Guangdong) who stayed on the same floor of Hotel M on 21 and 22 February and transmitted the disease to 13 guests, including a Canadian and a Hong Kong person, who in turn sparked off major epidemics in their respective countries. Upon return to Singapore on 25 February, they developed fever, and a few days later a dry cough, and were admitted on 1 March to two different hospitals in Singapore and isolated 6 days later. The first case in Singapore admitted to Tan Tock Seng Hospital infected 20 close contacts (11 health care workers, and 9 relatives or friends). These in turn infected 71 people (all health care workers, patients and relatives), who then contributed to the current epidemic in Singapore. Isolation and infection control for these patients was instituted on 6 March, hospital-wide infection control was enforced on 14 March, and Tan Tock Seng Hospital became the SARS designated hospital on 22 March.

Case 3 was unrelated to the first cases, but had been a guest at Hotel M in Hong Kong during the same period, and returned on 25 February. She developed a fever on 27 February, was admitted to Tan Tock Seng Hospital on 5 March, and was isolated the next day.

Cases 4 and 5 were a mother (42 years) and son (18 years) who had returned on 23 March from visiting relatives in Guangdong and Hong Kong. They developed symptoms within 2 days after arrival in Singapore, and were admitted and placed in isolation on 25 and 27 March respectively. The father and other son who had traveled with them were not infected.

Case 6 was a 29-year-old designer who had been on a business trip to Hong Kong and Beijing and developed high fever and a cough while in Beijing. She consulted two doctors in Beijing, but the diagnosis of SARS was not made at that time. She became very unwell and breathless on her return flight from Beijing to Singapore on 26 March, but no precautions were taken on the airplane, as her diagnosis was not known. Immediately after arrival, her mother took her in a taxi to Tan Tock Seng Hospital, where she was isolated in the Intensive Care Unit. She developed acute respiratory distress syndrome and multiorgan failure, and died 10 days later. Both the mother and the taxi driver were quarantined, but neither developed SARS. The Ministry of Health was able to contact 46 of the 47 passengers, as well as all 9 crew members, and they were put under home quarantine order and active surveillance for 10 days; none developed SARS.

Three of the six imported cases developed symptoms of SARS only after arrival in Singapore, whereas three had symptoms on the return flight to Singapore (cases 1 and 2, fever only, case 6, fever, cough, and shortness of breath). The first two were admitted to a hospital at a mean of 4 days after onset of symptoms, and placed in isolation 6 days later. Cases 3 to 6 had symptoms of SARS in Singapore for a mean of 2.5 days, and all were immediately placed in isolation after hospital admission (except case 3: after 1 day). Cases 1 and 2 were therefore without infection control measures for 10 days, and cases 3 to 6 for a mean of 3.6 days.

Only case 1 resulted in secondary transmission. No health care workers and no other contacts were infected by cases 2 to 6.

The table summarizes the six imported cases.

**Prevention of Importation of SARS**

To prevent further importation of SARS, the following measures were taken at the airports, seaports and road entry points into Singapore. From 30 March 2003, Health Alert Notices were issued to air passengers arriving from affected areas. On 31 March, visual screening was instituted for all passengers arriving from SARS-affected areas, and this was replaced by temperature screening a few days later. Passengers who appeared to be unwell or had a temperature of >37.5°C were sent by a special ambulance to a single hospital that had been nominated to perform SARS screening. From 7 April onwards, passengers arriving from SARS-affected countries were asked to complete health declaration cards. The information required included not only recent travel and contact history and symptoms suggestive of SARS, but also addresses in Singapore and flight seats, to facilitate contact tracing. On 23 April, thermal scanners were installed at Changi Airport and the road entry points to check the temperatures of all departing and arriving passengers. Temperature checks
were introduced to all of Singapore’s ferry terminals on 28 April. SARS screening was progressively extended to all arriving flights from 29 April onwards. After implementation of these screening methods, no further importation of patients with SARS occurred (31 March until 31 May). In total, 442,973 air passengers were screened between 31 March and 31 May 2003, and of those, 136 were sent to Tan Tock Seng Hospital for further SARS screening and observation, but none was diagnosed as having SARS.

The figure depicts the time of arrival of imported SARS in Singapore and measures taken.

**Discussion**

Our findings illustrate that not every imported case of SARS results in new disease clusters: only one of the six persons who imported SARS transmitted the disease in Singapore. The SARS epidemic in Singapore can be traced to this single person, who imported SARS before the WHO alert on 12 March at a time when the disease was not widely recognized. The experience with SARS in Singapore is therefore analogous to that in Hong Kong, Vietnam and Canada, where the first imported cases were associated with a large number of health-care-associated infections. By 31 May, the national epidemic had resulted in a total of 206 cases with probable SARS, with the large majority being directly or indirectly (secondary, tertiary, etc.) linked to this first imported case. The absence of community transmission associated with the SARS cases imported after appropriate public health measures were taken in Singapore is probably a result of relatively prompt identification and isolation together with a low potential for transmission (i.e. they were not superspreaders), whereas the absence of nosocomial transmission is probably due to the immediate isolation and enhanced infection control measures.

Singapore introduced a large number of measures to prevent further importation of SARS, at considerable cost and inconvenience. Our experience shows that no cases of SARS were identified by these measures. This is most likely due to a combination of factors, such as travel advisories which resulted in reduced travel to and from SARS-affected areas, implementation of effective predeparture screening at airports in SARS-hit countries, and a rapid decline in new cases worldwide since May 2003. Three of the six imported SARS cases developed symptoms only after arrival in Singapore, and would thus have been missed on airport screening. Therefore, screening measures at entry points are not sufficient in themselves. Health education for incoming passengers on recognition of SARS symptoms and advice to seek prompt consultation if symptoms develop therefore remain important additional public health measures.

Active surveillance of all passengers on flights with a SARS patient on board was only instituted from 24 March 2003, when the Infectious Disease Act was invoked in Singapore, and no in-flight transmission was documented. For the imported cases early in the epidemic, no active surveillance of passengers and crew was possible,
but systems were in place in Singapore for detection of SARS, and no cases were linked to any of these flights. Our findings raise the hope that new imported SARS cases need not lead to major outbreaks if systems are in place to identify and isolate them efficiently. Screening at entry points is costly and troublesome, has a low yield, and is not sufficient in itself. However, the medical, economic, social and international impact of one single imported SARS case, as shown by the Singapore experience, more than outweighs the costs of such measures and would justify them.

References

1. Outbreak of severe acute respiratory syndrome – worldwide, 2003. MMWR 2003; 52(11):226–228.
2. Lee N, Hui D, Wu A, et al. A major outbreak of severe acute respiratory syndrome in Hong Kong. N Engl J Med 2003; 348(20):1986–1994.
3. Poutanen SM, Low DE, Henry B, et al. Identification of severe acute respiratory syndrome in Canada. N Engl J Med 2003; 348(20):1995–2005.
4. Hsu LYLC, Green JA, Ang B, et al. Severe acute respiratory syndrome (SARS) in Singapore: clinical features of index patient and initial contacts. Emerg Infect Dis 2003; 9(6): 713–717.
5. Wilder-Smith A, Paton NI. Severe acute respiratory syndrome: imported cases of severe acute respiratory syndrome to Singapore had impact on national epidemic. BMJ 2003; 326:1393–1394.
6. Chan-Yeung M, Yu WC. Outbreak of severe acute respiratory syndrome in Hong Kong Special Administrative Region: case report. BMJ 2003; 326:850–852.
7. Severe acute respiratory syndrome – Singapore, 2003. MMWR 2003; 52(18):405–411.
8. Lipsitch M, Cohen T, Cooper B, et al. Transmission dynamics and control of severe acute respiratory syndrome. Science 2003; 300:1961–1966.
9. Riley S, Fraser C, Donnelly CA, et al. Transmission dynamics of the etiological agent of SARS in Hong Kong: impact of public health interventions. Science 2003; 300:1966–1970.