

SARS in Singapore – Key Lessons from an Epidemic

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Abstract

The rapid containment of the Singapore severe acute respiratory syndrome (SARS) outbreak in 2003 involved the introduction of several stringent control measures. These measures had a profound impact on the healthcare system and community, and were associated with significant disruptions to normal life, business and social intercourse. An assessment of the relative effectiveness of the various control measures is critical in preparing for future outbreaks of a similar nature. The very “wide-net” surveillance, isolation and quarantine policy adopted was effective in ensuring progressively earlier isolation of probable SARS cases. However, it resulted in nearly 8000 contacts being put on home quarantine and 4300 on telephone surveillance, with 58 individuals eventually being diagnosed with probable SARS. A key challenge is to develop very rapid and highly sensitive tests for SARS infection, which would substantially reduce the numbers of individuals that need to be quarantined without decreasing the effectiveness of the measure. Daily temperature monitoring of all healthcare workers (HCWs) in hospitals was useful for early identification of HCWs with SARS. However, daily temperature screening of children in schools failed to pick up any SARS cases. Similarly, temperature screening at the airport and other points of entry did not yield any SARS cases. Nevertheless, the latter 2 measures probably helped to reassure the public that schools and the community were safe during the SARS outbreak. Strong political leadership and effective command, control and coordination of responses were critical factors for the containment of the outbreak.

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The 2003 severe acute respiratory syndrome (SARS) outbreak represented the most severe communicable disease challenge to the public health system and the government and people of Singapore. The SARS outbreak in Singapore began on 1 March 2003 and the last case of the outbreak was isolated on 11 May 2003. During this period, a total of 206 probable SARS cases were diagnosed on the basis of the World Health Organization’s (WHO) case definition.¹ In the post-outbreak period, laboratory testing of samples from suspect and observational cases who had been admitted to the Tan Tock Seng Hospital (TTSH) identified a further 32 patients who were positive for SARS antibodies or had positive culture results for the SARS coronavirus.

The rapid containment of the SARS outbreak involved the imposition or introduction of multiple, stringent control measures, many of which were unprecedented. Each of these control measures had a profound and wide-ranging impact on the healthcare system and the broader community.

The disruptions to normal life, business and social intercourse associated with the implementation of these measures were generally well-accepted by the community at large, in the broader interest of containing the outbreak. However, there is a need to better understand the relative value and contribution of the different containment strategies to the management of the outbreak, as this would help inform decisions on the institution of these measures in the event of future outbreaks of a similar nature. To this end, much more research is required. This paper endeavours to review the key response measures which were deemed to have been important in contributing to the containment of the SARS outbreak in Singapore.

Three Key Features of the SARS Outbreak

Three key features of SARS coronavirus transmission were appreciated early in the course of the SARS outbreak, which had a major influence on the development of the containment efforts.¹

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Firstly, SARS was predominantly a nosocomial infection. At the start of the Singapore outbreak, of the 13 SARS cases notified to the Ministry of Health (MOH) by 15 March 2003, 7 were healthcare workers (HCWs). For the whole outbreak, of the 206 probable cases diagnosed clinically, 155 (78%), including 84 HCWs, had been acquired in hospital.

Secondly, while SARS is generally not very infectious with an average of 2 to 4 cases stemming from each primary case,^{1,2} a small number of SARS cases were associated with “superspreading events”, where the infection was transmitted to large numbers of individuals. In the Singapore outbreak, 5 patients were thought to account directly for infection to 121 of the 206 probable SARS cases.³ The reasons for “superspreading events” are still not clear, nor are there ways to predict which patients may be “superspreaders”.

Thirdly, it was painfully apparent early in the SARS outbreak that the clinical presentation of cases can be very broad and non-specific. For example, in patients in the Singapore outbreak who eventually developed probable SARS, about 30% did not have respiratory symptoms initially and a significant proportion presented with other symptoms such as diarrhoea.⁴ Atypical presentations made the early identification of SARS very difficult in such cases, and were a major factor contributing to the continued propagation of the Singapore SARS epidemic. For example, a patient in whom concomitant SARS infection had been “masked” by other severe medical problems, including documented gram-negative sepsis, community-acquired pneumonia and heart failure, accounted for transmission of SARS to 26 contacts in TTSH.⁵ Another patient, who similarly had an atypical presentation for SARS which was masked by an *Escherichia coli* bacteraemia and who did not manifest any respiratory abnormalities until late in the course of infection, was responsible for starting the SARS outbreak in the Singapore General Hospital.⁶

Containment of Hospital SARS Outbreaks

As SARS was predominantly a nosocomial infection, the major part of containment efforts was concentrated on hospitals. The strategies employed and the outcomes have been described in detail elsewhere.^{5,7} Table 1 summarises the time-line for the implementation of the key control strategies and measures.

Four measures were felt to be of particular importance. Firstly, the institution of a system of triage at the point of first patient contact with the hospital (i.e., at Emergency Departments, Outpatient Clinics and direct ward admissions) to separate out febrile patients. This allowed the early separation of potentially infectious patients so that their contact with other types of patients and unprotected

staff and members of the public could be minimised. Secondly, the enforced use of personal protective equipment (PPE) for all hospital staff, together with the adoption of strict infection control measures. Regular audits by MOH teams supplemented by internal audits by hospitals themselves helped ensure a high level of compliance. Thirdly, the practice of temperature monitoring of all hospital staff enabled the early detection and isolation of clusters of febrile HCWs. Fourthly, the designation of TTSH as the SARS hospital allowed the clinicians at that site to develop strong clinical expertise in the assessment, isolation and management of potential SARS cases.

Adoption of a Very “Wide-net” Surveillance, Isolation and Quarantine Policy

Realising that SARS can present atypically and that a single “superspreader” could cause a large cluster of SARS cases, the MOH adopted a very “wide-net” surveillance, isolation and quarantine policy to detect all suspicious cases as early as possible and to isolate them.

A very broad definition for suspicious cases was used. This included any HCW with fever and/or respiratory symptoms; patients with atypical pneumonia for which the cause had not been determined; clusters of 3 or more HCWs in the same work area with fever >38°C within 48 hours; clusters of inpatients that the hospitals had assessed to be cause for concern; and unexplained respiratory deaths.

Rapid contact tracing and public health decision making on cases were critical components of this wide-net surveillance and isolation policy. A daily epidemiology meeting chaired by the Director of Medical Services reviewed all suspicious cases and made decisions on contact tracing and quarantine. A contact tracing centre was established in the MOH, which together with a full-time team in TTSH to interview suspected cases, ensured that all contacts were traced within 24 hours. Contacts were placed on daily telephone surveillance or home quarantine, depending on the specifics of each case, within the same day.⁸

This “wide-net” approach to surveillance and isolation of suspected cases was effective in ensuring progressively earlier isolation of probable SARS cases as the outbreak progressed.⁷ This is illustrated in Table 2. The average duration between onset of symptoms to isolation for probable SARS patients decreased from 6.8 days in week 2 of the outbreak, to 1.3 days at week 9. At the same time, the percentage of probable SARS cases previously identified as suspect SARS cases progressively increased, to more than 80%. The percentage of probable SARS cases that had previously been on either home quarantine orders or on telephone surveillance also increased steadily, being 50% and 100% on weeks 8 and 9, respectively.

Table 1. Time-line for the Implementation of the Key Control Strategies and Measures

Date	Key measures implemented
13.3.2003	WHO's global alert on SARS MOH's directive to isolate all cases of atypical pneumonia
14.3.2003	MOH advisory to the public to avoid travel to SARS-affected countries
16.3.2003	Triage at Emergency Departments to separate out febrile patients from other types of patients and unprotected staff and members of the public
22.3.2003	Strict infection control measures in all high risk clinical areas in all hospitals. Tan Tock Seng Hospital designated as the SARS hospital. Home quarantine and daily telephone surveillance of contacts with suspected SARS cases
7.4.2003	Formation of the Ministerial Committee on SARS chaired by the Minister for Home Affairs
8.4.2003	MOH directive under the Private Hospitals and Medical Clinics Act requiring all hospitals and nursing homes to ensure effective implementation of detailed procedures on triage, isolation, use of personal protective equipment and infection control
9.4.2003	Passengers of all inbound aeroplane flights required to complete a Health Declaration Card. Thermal scanners deployed at airport
ca 30.4.2003	Mandatory temperature screening of children in schools

MOH: Ministry of Health; SARS: severe acute respiratory syndrome; WHO: World Health Organization

Table 2. Probable SARS cases by week of outbreak, for weeks 1, 2 and 9, showing the numbers (%) who were previously diagnosed as suspect SARS cases, the duration between time of onset of SARS symptoms to isolation, and the numbers (%) who had previously been on home quarantine orders (HQO) or daily telephone surveillance

Week of outbreak	Period	Number of probable cases	Cases who were previously diagnosed as suspect SARS	Average duration between onset of SARS symptoms and isolation in TTSH (days)	Number of cases previously on HQO	No. of cases previously on daily phone surveillance	Total no. of cases on HQO or surveillance	
Week 1	24/2/03 - 2/3/03	2	0	0.0	4.3	0	0	0
Week 2	3/3 - 9/3	15	0	0.0	6.8	0	0	0
Week 9	21/4 - 27/4	8	7	87.5	1.3	2	6	8

HQO: home quarantine orders; SARS: severe acute respiratory syndrome; TTSH: Tan Tock Seng Hospital

Not unexpectedly, the “wide-net” surveillance and isolation policy resulted in very large numbers of individuals being quarantined or placed on phone surveillance, who eventually turned out not to have SARS. During the SARS outbreak, nearly 8000 contacts were served home quarantine orders while at least a further 4300 were put on daily telephone surveillance for 10 days. In total, 58 of the 206 probable SARS cases had been on either home quarantine orders or on telephone surveillance prior to their diagnosis.

Clearly, a very critical challenge going forward is to develop rapid and highly sensitive tests for SARS infection, which would substantially reduce the numbers of individuals that need to be quarantined without decreasing the effectiveness of the measure.

It should also be noted that a “wide-net” surveillance, isolation and quarantine policy probably worked for SARS because of a number of specific characteristics of the infection. Firstly, SARS patients are infectious only when they develop symptoms, and the risk of secondary infection markedly increases after >8 days from the onset of symptoms. The corollary is that there is little or no significant

asymptomatic SARS infection and transmission. Secondly, SARS is transmitted predominantly through close contact and droplet spread, or through contact with contaminated fomites. It therefore follows that the surveillance, isolation and quarantine policy is likely to have limited impact on the containment of infectious diseases which are transmitted by asymptomatic individuals, which are highly infectious early in the course of symptomatic illness and/or are spread by the aerosol route.⁷

Temperature Screening in Hospitals and in the Community

Strict twice- or thrice-daily temperature monitoring of all HCWs was first introduced by TTSH early in the course of the SARS outbreak. It was subsequently mandated by the MOH for all other healthcare facilities. During the outbreak, temperature monitoring of HCWs was useful in enabling the early identification and isolation or quarantine of individuals who might have had SARS.⁴

Temperature screening was subsequently extended to institutions in the general community, and in particular to

schools. Twice-daily temperature monitoring of all school children from 6 to 16 years of age was made mandatory during the period 30 April to 25 July 2003. In total, nearly half a million children had mandatory temperature screening during this period. Students were not allowed to attend school if their temperature reading was $>37.8^{\circ}\text{C}$ for students ≤ 12 years old or $>37.5^{\circ}\text{C}$ for students >12 years old. Sixty-seven students who had persistently elevated temperature readings (defined as ≥ 2 temperature readings above the cut-off temperatures per week for >2 consecutive weeks) and no contact history with SARS and/or travel history to a country with SARS within the previous 10 days, had more detailed clinical evaluation in a special clinic established by the MOH. Despite this extensive effort, none of the Singapore children diagnosed with SARS were detected through school temperature screening.⁹ However, it is likely that the screening procedures had a powerful psychological effect of reassuring parents and the public that schools were safe during the SARS outbreak, an important consideration which cannot be discounted.

Preventing the Importation (and Exportation) of SARS Through Temperature Screening at the Airport and Seaports

A constant worry during the SARS outbreak was the possibility that new “imported” cases of SARS could lead to fresh outbreaks of the disease in Singapore. Several measures were taken to reduce this possibility. On 14 March, MOH issued advice to the Singaporean public to avoid travel to SARS-affected countries unless absolutely necessary. On 30 March, Health Alert Notices were issued at the airport to inbound air-passengers from affected areas, highlighting the common symptoms of SARS and advising the passenger to seek immediate medical attention at TTSH should they have fever. On 9 April, passengers of all inbound flights were required to complete a Health Declaration Card, providing information on whether they had symptoms of SARS and the areas that they had travelled to in the preceding 10 days. Thermal scanners developed by Singapore’s Defence Science and Technology Agency were deployed at the airport to allow rapid temperature screening of all passengers on inbound and, later, outbound flights. This was later extended to the seaports and road links with Malaysia.

While these measures were a key component of the overall SARS prevention strategy, the yield was very low. By 21 September 2003, 4044 travellers were detected to have temperatures $>37.5^{\circ}\text{C}$ through screening at the airport and sea terminals. Of these travellers, 327 were referred to TTSH for assessment and 39 were admitted for further evaluation and isolation. However, no cases of SARS were detected. Singapore had 6 imported SARS cases, excluding the initial index case. None of these cases had been picked

up by screening at the airport but had presented to hospital subsequently when fever developed. However, it should be noted that the last imported case was admitted to hospital on 2 April, and this was prior to the institution of temperature screening through thermal scanners at the airport. A recent analysis carried out by Pitman and co-workers concluded that entry screening at airports is unlikely to prevent the importation of either SARS or influenza.¹⁰

Strong, Effective Command, Control and Coordination of Responses

In any rapidly evolving crisis, strong, effective leadership is critical. This was very clearly demonstrated in the case of the Singapore SARS outbreak, where strong, decisive and open political leadership was a central element that resulted in the rapid containment of the epidemic. It was also very important that the political leadership was backed by effective command, control and coordination systems that ensured that strategies and decisions were properly implemented.

A Ministerial Committee on SARS was formed on 7 April 2003. It was chaired by the Minister for Home Affairs and included the Ministers for Health, Education, National Development and Manpower. The Ministerial Committee maintained a high-level oversight of the formulation and implementation of operational response plans for various scenarios, helped resolve cross-Ministry policy issues and provided political guidance to handle the impact of SARS on the society and economy. The Ministerial Committee was supported by the Executive Group, chaired by the Permanent Secretary of the Ministry of Home Affairs and comprised the Permanent Secretaries of key Ministries. The Executive Group ensured the coordinated implementation of containment measures. The SARS Taskforce, set up by the MOH on 15 March, included the clinical leadership and Chief Executive Officers of all hospitals, and infectious disease physicians and other experts. Chaired by the Director of Medical Services, the Taskforce focused on public health measures to contain the SARS outbreak, and on maintaining the provision of medical services.

Two critical lessons from the SARS epidemic are highly relevant for the command, control and coordination of responses in future infectious disease outbreaks. The first is the necessity of adapting rapidly to changing information and circumstances. Today, it is very easy to forget that in the initial weeks of the SARS outbreak, very little was known about the disease, its causation and transmission, and the likelihood that various containment strategies would be successful in curtailing the epidemic. In the 2003 SARS epidemic, new containment measures were instituted and existing ones were regularly modified as more was progressively understood about the spectrum of clinical

presentations of SARS, the utility of the new diagnostic tests for SARS infection, and the modes of transmission of the disease. The second key lesson is the critical importance of rapid and accurate information collation and transmission, to guide decision-making and to keep HCWs, members of the public and the international community informed in a timely manner. This requires the standardisation of the criteria and processes for diagnosing and categorising suspected SARS cases, and excellent information technology (IT) systems. In the initial weeks of the SARS outbreak, information collection, dissemination and analysis were largely done manually. At that time, the IT systems for outbreak containment were inadequate for the demands and pace of the outbreak. This resulted in information gaps and delays that hampered timely public health response measures. By mid- to late-April 2003, however, much better and integrated IT systems were developed to support the containment efforts and these greatly facilitated isolation, contact tracing and quarantine of contacts.

Effectively Engaging the Public

The SARS outbreak resulted in a great deal of anxiety and fear in communities throughout the world. The successful containment of public anxiety and its re-direction into a positive force for community bonding and action, was arguably one of the most important aspects of the Singapore SARS experience. Several elements are likely to have been important in this regard. The timely and transparent provision of updated information on SARS and the local SARS situation was very important given the great deal of information and mis-information on SARS circulating through a wide range of formal and informal channels. The role played by the government was clearly critical in effectively explaining the containment strategies and the efforts to keep the general public safe by “ring-fencing” all possible SARS cases; mobilising governmental and voluntary community bodies to assist in the fight against SARS; successfully engaging the public on the steps which they should take to reduce the risk of spreading and contracting SARS; and highlighting the dedication of front-line HCWs. This latter point found resonance with the general public, and the huge wave of public support and goodwill was a critical factor in bolstering the morale of front-line medical staff.

A survey of 1086 respondents carried out by the Health Promotion Board from 30 April 2003 to 13 May 2003, found that about 93% were satisfied or very satisfied with the government’s response to SARS. Another study carried out during the SARS outbreak,¹¹ reported a relatively low

level of anxiety, with most respondents (68%) indicating that they thought that they were not very likely or not likely at all to contract SARS. Respondents had a generally high opinion of the handling of the crisis by the authorities, with more than 80% reporting that they thought official information was accurate, clear, sufficient and trustworthy.

Conclusion

The SARS outbreak of 2003 exacted a heavy toll in terms of the patients who contracted the infection and those who succumbed to it, and the profound and wide-ranging impact on Singapore’s economy and society. However, the SARS outbreak also had its positive aspects and consequences. Today, the public health and healthcare system is at a much higher level of preparedness against infectious disease threats. Very importantly, the government, healthcare system and people of Singapore had passed a severe test with distinction, an achievement which should stand Singapore in good stead for future challenges of a similar nature.

REFERENCES

1. Tan CC. SARS in Singapore: looking back, looking forward. *Ann Acad Med Singapore* 2003;32(Suppl):S4-S5.
2. Skowronski DM, Astell C, Brunham RC, Low DE, Petric M, Roper RL, et al. SARS – a year in review. *Annu Rev Med* 2005;56:357-81.
3. Centers for Disease Control and Prevention. Severe acute respiratory syndrome – Singapore, 2003. *MMWR Morb Mortal Wkly Rep* 2003; 52:405-11.
4. Tai YH. Severe acute respiratory syndrome. *Medical Progress* 2005; 317-24.
5. Gopalakrishna G, Choo P, Leo YS, Tay BK, Lim YT, Khan AS, et al. SARS transmission and hospital containment. *Emerg Infect Dis* 2004; 10:395-400.
6. Chow KY, Lee CE, Ling ML, Mok KH, Yap SG. Outbreak of severe acute respiratory syndrome in a tertiary hospital in Singapore linked to an index patient with atypical presentation: epidemiological study. *BMJ* 2004;328:195-8.
7. Tan CC. Public health response: A view from Singapore. In: Peiris M, Naderson AJ, Osterhaus BDME, Stohr K and Yuen KY, editors. *Severe Acute Respiratory Syndrome*. Oxford: Blackwell Publishing, 2005: 139-64.
8. Ooi PL, Lim S, Chew SK. Use of quarantine in the control of SARS in Singapore. *Am J Infect Control* 2005;33:252-7.
9. Chng SY, Chia F, Leong KK, Kwang YP, Ma S, Lee BW, et al. Mandatory temperature monitoring in schools during SARS. *Arch Dis Child* 2004;89:738-9.
10. Pitman RS, Cooper BS, Trotter CG, Gay NJ, Edmunds NJ. Entry screening for SARS or influenza: Policy evaluation. *BMJ* 2005;331: 1242-3.
11. Quah SR, Lee HP. Crisis prevention and management during the SARS Outbreak, Singapore. *Emerg Infect Dis* 2004;10:364-8.