*Epidemiol. Infect.* (2006), **134**, 786–791. © 2005 Cambridge University Press
doi:10.1017/S095026880500556X Printed in the United Kingdom

# The SARS outbreak in a general hospital in Tianjin, China – the case of super-spreader

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(*Accepted 19 September 2005, first published online 22 December 2005*)

## SUMMARY

Severe acute respiratory syndrome (SARS) is a newly emerged infectious disease with a high case-fatality rate and devastating socio-economic impact. In this report we summarized the results from an epidemiological investigation of a SARS outbreak in a hospital in Tianjin, between April and May 2003. We collected epidemiological and clinical data on 111 suspect and probable cases of SARS associated with the outbreak. Transmission chain and outbreak clusters were investigated. The outbreak was single sourced and had eight clusters. All SARS cases in the hospital were traced to a single patient who directly infected 33 people. The patients ranged from 16 to 82 years of age (mean age 38·5 years); 38·7% were men. The overall case fatality in the SARS outbreak was 11·7% (13/111). The outbreak lasted around 4 weeks after the index case was identified. SARS is a highly contagious condition associated with substantial case fatality; an outbreak can result from one patient in a relatively short period. However, stringent public health measures seemed to be effective in breaking the disease transmission chain.

## INTRODUCTION

Severe acute respiratory syndrome (SARS) is a newly emerged disease associated with a high case-fatality rate and the potential for devastating socio-economic impact. While it spread quickly to many parts of the world within a short time period after it was first recognized in Guangdong, China, November 2002 [1], large-scale outbreaks occurred in only a few areas [2–8]. As SARS is a largely unfamiliar disease, epidemiological and clinical studies from infected areas are of particular importance for us to understand it and to be better prepared for potential future outbreaks. In this paper, we present the epidemiological and clinical findings associated with a SARS outbreak in one hospital in Tianjin, China. As the aetiology of SARS was unknown during the outbreak, the WHO SARS case definitions were used, which were based on available clinical and epidemiological data. A suspect case was a person who had a SARS contact history and presented with high fever (>38 °C) and at least one respiratory symptom. A suspect case with radiographic evidence of infiltrates consistent with pneumonia or respiratory distress syndrome was a probable SARS case.

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## METHODS AND RESULTS

### Description of the outbreak

Like Beijing, Shanghai, and Chongqing, Tianjin is one of the four municipalities directly under the control of the Central Government of the People's Republic of China. Tianjin is the fourth largest city in China with a population of around nine million. It is a port city located 120 km south-east of Beijing. It is estimated that about half a million people travel each day between the two cities. Travel between Beijing and Tianjin was gradually reduced after the World Health Organization (WHO) issued a global alert on SARS on 12 March 2003. Casual travelling between the two cities virtually halted after mid-April when a large-scale SARS outbreak in Beijing occurred.

Pingjin Hospital (Hospital P) is a 400-bed general hospital located in downtown Tianjin. It had 41 clinical and 14 non-clinical departments at the time of the outbreak. Its 700 hospital staff included 169 physicians, 230 nurses, 267 other clinical supporting staff, and 34 non-clinical related administrators. When the outbreak started, there were 440 patients receiving medical treatment in Hospital P. Thus, the total number of potentially exposed people at Hospital P was 1140.

### The index case

Although people with SARS contact histories were advised not to leave Beijing after the outbreak started there in March 2003, a 54-year-old male (patient M) with a clear SARS contact history left Beijing on 15 April. While being treated for a heart condition in a hospital in Beijing, patient M shared a ward with patient H, who was later diagnosed with SARS. Afraid of being infected by SARS, Patient M left Beijing and presented on the same day at the cardiovascular department in Hospital P in Tianjin, seeking treatment for his coronary disease, type II diabetes, and chronic renal failure. He was seen by an attending cardiologist who had no respiratory protection. He was admitted to Hospital P the same day for further cardiovascular evaluation and treatment. On admission, clinical examination showed a temperature 36·4 °C, normal blood counts and differentials, and normal chest radiographs. On 16 April, the next morning, patient M had a fever of 37·6 °C; he complained of myalgia, a sore throat and a mild productive cough. Patient M's temperature reached 38·5 °C in the afternoon. A new chest radiograph was abnormal, but there were no obvious changes in blood count and classification (WBC $6{\cdot}3 \times 10^9$/l, GRN 88%).

### The spread of SARS

Patient M's clinical symptoms and examination results made one attending physician suspect SARS. Further investigation revealed the contact history with SARS in the Beijing hospital. Based on his clinical symptoms and contact history, patient M was immediately listed as a suspect SARS case. At 11:30 hours on 17 April, he was transferred to Tianjin Thorax Disease Hospital. He was treated there for 2 days before being transferred again to Tianjin Infectious Disease Hospital on 19 April at around midnight, where he died. Cases occurred after exposure to patient M in both these other hospitals and have been documented elsewhere [8]. Briefly, 164 of the total 175 SARS in this city can be traced to patient M [8].

During his stay in Hospital P, patient M was seen by a number of medical personnel. Figure 1 shows the infection chain associated with the SARS outbreak in Hospital P, Tianjin. Of the 1140 hospital staff and patients in this hospital at the time, 111 were diagnosed as either suspect or probable cases. The crude attack rate was 9·7%. Among all cases observed in this hospital, 33 were infected directly from patient M and 89 of all 111 SARS patients in the hospital could be traced to him. The latent period for the secondary cases varied from 2 to 11 days with a median latent time of 4 days. The outbreak started on 16 April, peaked on 24 April and lasted until 12 May (Fig. 2). The Table shows distribution by department of SARS patients. Of the 111 people who became infected in Hospital P, 81·1% (90/111) of them were probable cases. The SARS infection pattern in Hospital P is consistent with a person-to-person transmission pattern. Cardiology Unit I, where the index patient was first seen, had the highest number of SARS patients.

### Disease control

On 20 April, the day after the index patient died, stringent quarantine measures were enacted in the city of Tianjin to prevent SARS from spreading further. Hospital P was virtually sealed and guarded by armed police; hospital staff as well as patients were not

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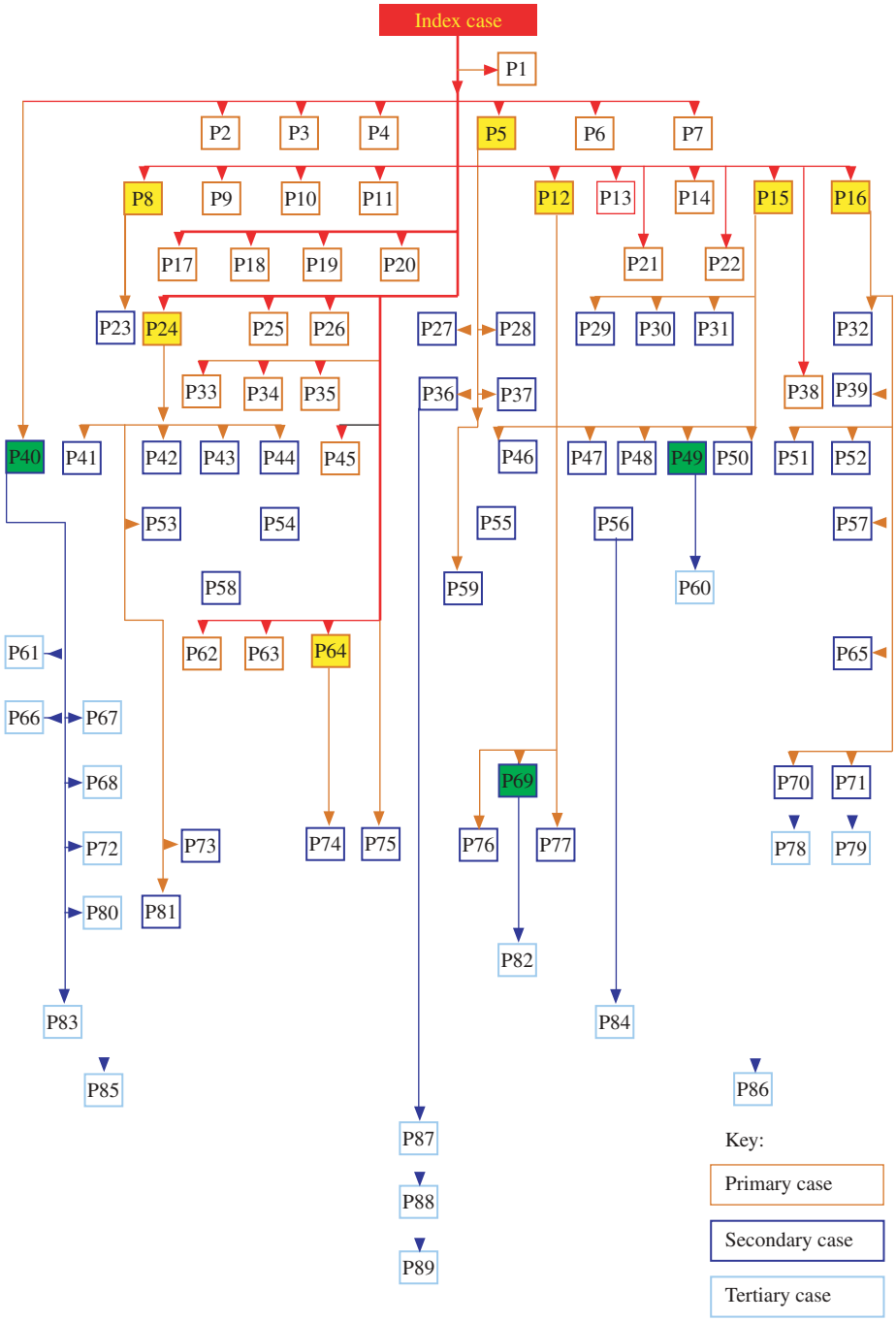


**Fig. 1.** Infection chain associated with the SARS outbreak in Hospital P, Tianjin. New generation of cases in boxes with colour fill (yellow = secondary cases; green = tertiary cases). Detailed contact history is unknown for P55, P56, P58, P78, P79, P85, P86, P88 and P89.

allowed to leave. Food and medical supplies were provided through a special arrangement, which ensured no cross-contamination between people inside and outside the hospital. Inside Hospital P, red, orange, and green codes were used to mark areas with high, medium and low contamination levels, respectively. Red areas included the departments that had either SARS cases and/or close contact with the departments with SARS patients. Orange areas included those departments without SARS or probable SARS cases but were believed to have some exposure to SARS infection. The SARS control office and outside hospital environment were classified as green areas.

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Table. *Crude attack rate by department in Hospital P, Tianjin, China*

| | No. of susceptible people | SARS cases | | | Attack rate* (%) |
|---|---|---|---|---|---|
| | | Probable | Suspect | Total cases | |
| Cardiology unit I | 88 | 38 | 3 | 42 | 47·7 |
| Cardiology unit II | 76 | 14 | 7 | 21 | 27·6 |
| Respiratory disease | 87 | 8 | 2 | 10 | 11·5 |
| Neurology | 92 | 6 | 0 | 6 | 6·5 |
| Maintenance | 55 | 6 | 0 | 6 | 10·9 |
| Burn | 53 | 3 | 2 | 5 | 9·4 |
| Emergency | 29 | 2 | 1 | 3 | 10·3 |
| Surgery | 89 | 3 | 1 | 4 | 4·5 |
| All others | 575 | 10 | 5 | 14 | 2·5 |
| Total | 1140 | 90 | 21 | 111 | 9·7 |

* Attack rates were calculated based on total cases.

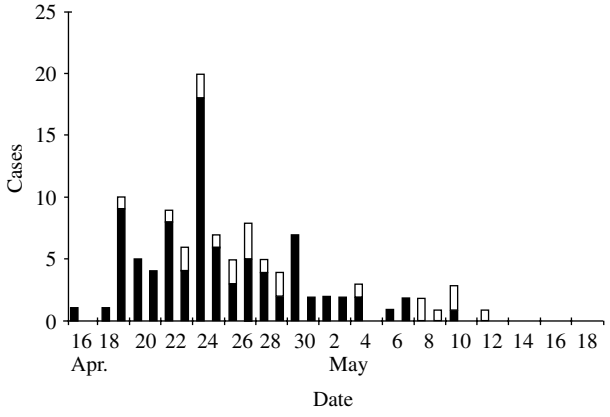


**Fig. 2.** The epidemic curve of the SARS outbreak in Hospital C, Tianjin, China. □, Suspect cases; ■, probable cases.

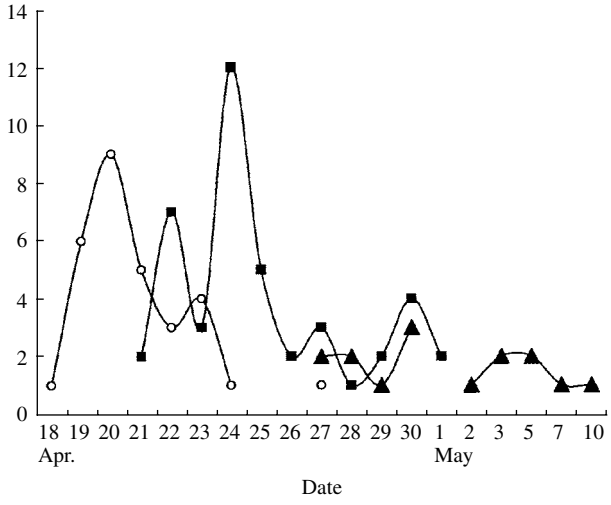


**Fig. 3.** The generation of SARS cases in Hospital P, Tianjin China (according to contact history). –○–, First generation; –■–, second generation; –▲–, third generation.

Corresponding differential protective measures were used in these three areas. A protective cap, a 12-layer gauze mask, protective glasses, gloves and a 2-layer gown, and occasional protective boots, were required for people working in the red areas. Special protective measures were needed only when in contact with the suspect cases. In the orange areas, protective caps, 12-layer gauze masks, gloves and 1-layer gowns were required. In green areas, only a mask was required. Red areas were further classified into suspect and probable SARS case areas. Different areas were managed by regulating the entry and changing of protective suits when moving between areas. From 20 April to 20 June, protective supplies used were: 502 920 protective suits, 133 729 masks, 72 284 disposable caps, 97 120 pairs of gloves, and 14 112 pairs of protective goggles.

In response to these stringent infection control measures, the transmission of SARS seemed to diminish after the peak of 24 April (Fig. 2). Figure 3 depicts the epidemic curves associated with the three generations of SARS patients in this outbreak, defined in relation to the index case. Those who became infected directly from the index case were regarded as first-generation cases. The second- and third-generation cases were infected by first- and second-generation cases respectively.

The three generations of SARS cases started from 18, 21 and 28 April respectively (Fig. 3). However, there were substantial overlaps among the three generations of cases. The last SARS patient was

https://doi.org/10.1017/S095026880500556X Published online by Cambridge University Press

reported on 12 May 2003 and the stringent quarantine in Tianjin ended on 20 June 2005.

## DISCUSSION

SARS is a new disease, which had a high case fatality, and an unknown agent and transmission mode at the time of the outbreak. We fought SARS as a learning process. In the outbreak reported in this paper, many clinical units were affected and a substantial proportion of caregivers infected. Several lessons can be learned from the early stage of the outbreak in Tianjin. First, unaware of the SARS outbreak in Beijing, there was no emergency contingency plan set-up in Tianjin in early April to screen people from Beijing. As a result, a number of medical professionals had unprotected contacts with the index case. Second, after the index case was diagnosed as having SARS, the initial protective measures were unable to protect caregivers, which caused the further spread of this disease. Third, in a retrospective view, the index case was transferred to two different hospitals before adequate protective measures were in place. Consequently, SARS infection also occurred in other hospitals and beyond.

However, the SARS outbreak in Hospital P as well as in Tianjin came under control after Tianjin municipal authorities, at various levels, acted aggressively to implement stringent measures to enhance active surveillance, isolate SARS patients, and quarantine those having possible contact with SARS patients. These measures proved effective and SARS transmission was halted. Compared with the outbreak in Beijing [9–11] where effective SARS control was delayed for several weeks, stringent transmission control measures in Tianjin started sooner (i.e. 4 days) after the index case was identified. As a result, there were fewer community transmissions in Tianjin and a large proportion of SARS cases occurred within medical settings [12]. The number of cases from Hospital P accounted for 51·4% of the SARS cases in Tianjin.

As with the Toronto SARS outbreak [8–13], the outbreak in Tianjin was initiated by a single patient from Beijing. The index case was treated in three hospitals in Tianjin and infected a large number of persons. In Hospital P alone, 33 SARS patients were directly infected by the index case. The term SARS 'super-spreader' has been used to describe certain individuals who have been implicated in spreading SARS to numerous other individuals. SARS super-spreaders were noticed in several SARS outbreaks in 2003 [8, 14, 15]. The SARS outbreak in Tianjin as described in this paper seems typical of an outbreak associated with super-spreaders. While it is not clear whether super-spreaders are associated with more contagious viral strains or simply a result of unprotected natural transmission, it highlights the critical importance of early intervention in controlling SARS transmission.

There are some limitations to our study. Due to the uncertain natural history of this disease and the lack of any clear diagnostic criteria, there may have been some misclassification. It is difficult to estimate the nature and the magnitude of this. During the SARS outbreak, as much effort was devoted to implementing disease control measures, epidemiological information collected from SARS patients was limited and we were constrained by the data available to us. For example, detailed information with respect to the types of protective measures used by health professionals and patients at Hospital P for the first few days was not available. Finally, this study only describes the outbreak in Hospital P. Most of the SARS cases in Tianjin occurred in this hospital. Thus, this study reflects one major component of the outbreak of SARS in Tianjin, providing a snapshot of a SARS outbreak in one hospital. Our findings add to our understanding of disease control, which may help us to better prepare to confront other emerging diseases in the future.

## ACKNOWLEDGEMENTS

The authors thank all health workers at CPAPF Medical College and Tianjin CDC who worked tirelessly during the SARS outbreak. We also pay tribute to the health workers who lost their lives as the result of the SARS outbreak.

## DECLARATION OF INTEREST

None.

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