



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

# Risk of Transmission of Severe Acute Respiratory Syndrome to Household Contacts by Infected Health Care Workers and Patients

Louis Y. Chan, MD, MPH, John T. W. Wong, MD, Philip K. T. Li, MD, S. F. Lui, MD, Hong Fung, MD, Joseph Sung, MD

Within a short period of time, severe acute respiratory syndrome (SARS) became a major global health hazard. Indeed, the high infectivity and serious morbidity and mortality of this condition created panic around the world. Despite increasing knowledge regarding the clinical course and treatment of patients with SARS, there is little information on the risk of disease transmission to household contacts by infected health care workers and patients.

## METHODS

All patients and health care workers with SARS at five hospitals in Hong Kong (Prince of Wales Hospital, Alice Ho Miu Ling Nethersole Hospital, Tai Po Hospital, North District Hospital, and Shatin Hospital) were included in the study. The study period was from February 28 to June 8, 2003. The case definition of SARS by the Centers for Disease Control and Prevention was used (1).

In March 2003, there was a major SARS outbreak in Hong Kong. From March 6 to 11, more than 50 health care workers were infected; subsequently, personal protective equipment was required for all health care workers. We divided the study subjects into three groups: health care workers who were infected because of unprotected exposure (before March 12), health care workers who were infected after implementation of compulsory protective measures, and patients (i.e., non-health care workers). Because we sought to evaluate the disease transmission rate in household members, subjects who were infected in hospital and had not been discharged home, and thus had no close contact with household members, were excluded.

All patients and health care workers admitted with SARS were interviewed by a nurse or doctor, and information on personal details and the number of household contacts was collected. We searched the SARS registry (2), a mandatory reporting of SARS cases by the Government of Hong Kong, to determine if any persons living in the same household as infected persons were also diagnosed with SARS.

## Statistical Analysis

The Fisher exact test, chi-squared test, or one-way analysis of variance was used, where appropriate. A *P* value <0.05 was considered statistically significant. Statistical analysis was performed using SPSS software, version 10.0 (SPSS Inc, Chicago, Illinois).

## RESULTS

The study included 268 subjects with SARS (Table): 99 patients, 67 health care workers infected before implementation of infection control measures, and 102 health care workers infected after implementation of the rule. Most subjects (91% [*n* = 243]) lived with at least 1 other person. The mean number of household members was 2.6 for health care workers and 2.7 for patients. The mean ( $\pm$  SD) age among patients was  $62.9 \pm 19.0$  years, and 34% were older than 75 years. The mean duration from illness onset to hospitalization was significantly shorter among health care workers infected after implementation of infection control measures compared with other subjects (*P* <0.05; Table).

Only 30 of the 243 (12.3%) SARS subjects who lived with another person transmitted the disease to household members (Table). Twenty-four of these 30 subjects were non-health care workers. Significantly more patients infected their household members (26.1%) compared with health care workers infected before (9.8%) and after (0%) implementation of infection control measures (*P* <0.05).

A total of 75 household members lived with the 30 SARS subjects who transmitted the disease, of whom 61 (81.3%) contracted SARS. The rate of infection was significantly higher among household members who were in contact with patients than among those who lived with health care workers infected before implementation of protective measures (86.4% vs. 62.5%, *P* <0.05). The overall rate of infection among household members (when all susceptible household members were included) was 8.8% (61/697), with those in contact with patients having a higher overall rate (Table).

## DISCUSSION

Our study showed that the overall rate of SARS infection among household members was 8.8%, which is lower than the rates associated with other infectious diseases that are spread by respiratory droplets, such as human parvovirus B19 (70%) (3) and *Mycoplasma pneumoniae* (15%) (4). Although only about 10% of infected persons transmitted the virus to household members, a large percentage of household members were infected. These observations suggest that there is a large variability in infectivity among SARS patients, with a small proportion appearing to be more infectious and more likely to transmit the disease to close contacts than others. This might

**Table.** Characteristics of SARS Transmission to Household Members by Infected Health Care Workers and Patients

	Health Care Workers			Total (n = 268)
	Infected before Implementation of the Protective Equipment Rule (n = 67)	Infected after Implementation of the Protective Equipment Rule (n = 102)	Patients (n = 99)	
	Number (%) or Mean $\pm$ SD			
Age (years)	30.8 $\pm$ 8.8	34.7 $\pm$ 9.6	62.9 $\pm$ 19.0*	44.3 $\pm$ 20.3
Duration from illness to hospitalization (days)	3.9 $\pm$ 3.4*	2.4 $\pm$ 2.0	3.4 $\pm$ 3.9*	3.0 $\pm$ 3.1
Living with other persons	61 (91.0)	90 (88.2)	92 (92.9)	243 (90.7)
Subjects who had infected their household members	6 (9.8)	0	24 (26.1)*†	30 (12.3)
Infected household members/total household members	10/16 (62.5)*	0	51/59 (86.4)*†	61/75 (81.3)
Subjects who had not infected their household members	55 (90.2)	90 (100)	68 (73.9)	213 (87.7)
Household members	155	261	206	622
Overall transmission rate	10/171 (5.8)*	0/261 (0)	51/265 (19.2)*†	61/697 (8.8)

\* Compared with health care workers infected after implementation of the protective equipment rule ( $P < 0.05$ ).

† Compared with health care workers infected before implementation of the protective equipment rule ( $P < 0.05$ ).

SARS = severe acute respiratory syndrome.

be related to the difference in viral load among different patients. Identification of highly infectious SARS patients will facilitate infection control.

We found the incidence of household transmission of SARS by infected health care workers to be significantly lower than by patients. Indeed, more than a quarter of patients had infected their household members compared with 10% of health care workers infected before implementation of the protective equipment rule. This might be because many patients were elderly and required assistance for daily activities from household members. Moreover, clinical presentation tends to be atypical in elderly SARS patients (5), who often do not have the typical symptoms of high fever, chills, and rigors. The atypical presentation may delay hospitalization and increase the risk of transmission to household members.

There were no cases of household transmission by health care workers infected after implementation of the protective equipment rule. This might be partly due to the significantly shorter time between illness onset and hospital admission. Because of the possibility of SARS infection despite use of personal protective equipment, many health care workers are concerned about becoming infected and transmitting the virus to household members. Once these workers developed symptoms, they would seek medical attention and be admitted early, which would reduce their contact with household members.

SARS is a highly contagious condition that poses a constant threat to health care workers, patients, and their household members. Early diagnosis of SARS is difficult because the sensitivity of testing with polymerase chain

reaction is still far from optimal (sensitivity of 50% to 72%) (6). Before an accurate diagnostic test becomes available, a high level of alertness and early medical attention is the only way to reduce the risk of household transmission.

## REFERENCES

- Centers for Disease Control and Prevention. Severe acute respiratory syndrome (SARS) updated interim case definition. Available at: <http://www.cdc.gov/ncidod/sars/casedefinition.htm>. Accessed June 28, 2003.
- Surveillance, information and data management. In: SARS in Hong Kong: From Experience to Action. Hong Kong, SAR China: Hong Kong Government Press; 2003;115–119.
- Azzi A, Trotta M, Zakrzewska K, et al. Human parvovirus B19 infection within a family and risk for pregnant women. *Epidemiol Infect.* 1996;117:401–403.
- Dorigo-Zetsma JW, Wilbrink B, van der Nat H, et al. Results of molecular detection of *Mycoplasma pneumoniae* among patients with acute respiratory infection and in their household contacts reveals children as human reservoirs. *J Infect Dis.* 2001;183:675–678.
- Kong TK, Dai DL, Leung MF, et al. Severe acute respiratory syndrome (SARS) in elders. *J Am Geriatr Soc.* 2003;51:1182–1183.
- Yam WC, Chan KH, Poon LL, et al. Evaluation of reverse transcription-PCR assays for rapid diagnosis of severe acute respiratory syndrome associated with a novel coronavirus. *J Clin Microbiol.* 2003;41:4521–4524.

From Hospital Administration (LYC, HF), Prince of Wales Hospital (JTWW, PKTL, SFL, JS), and Department of Medicine and Therapeutics (JTWW, PKTL, SFL, JS), The Chinese University of Hong Kong, Shatin, Hong Kong, SAR China.

Requests for reprints should be addressed to Louis Y. Chan, MD, MPH, Department of Obstetrics and Gynaecology, Block E, 1st Floor, Prince of Wales Hospital, Shatin, Hong Kong, SAR China, or [chanysl@ha.org.hk](mailto:chanysl@ha.org.hk).

Manuscript submitted June 30, 2003.