For information

SARS Expert Committee

Research materials provided by Prof Joseph Lau of the Chinese University of Hong Kong

This paper attaches for Members' reference a letter dated 31 July 2003 from Prof Joseph Lau, Director of Centre for Clinical Trials and Epidemiological Research, Faculty of Medicine, Chinese University of Hong Kong and some attached research materials on SARS.

Members are requested to note that the research materials are still being peer reviewed for publication, and are therefore provided for Members' personal reference only.

SARS Expert Committee Secretariat
August 2003

FACULTY OF MEDICINE
THE CHINESE UNIVERSITY OF HONG KONG
香港中文大學
醫學院

Telephone : (852)2637-4755 Fax : (852)2645-3098 E-mail : ccter@cuhk.edu.hk Web site : www.ccter.cuhk.edu.hk

CENTRE FOR CLINICAL TRIALS AND EPIDEMIOLOGICAL RESEARCH

臨床實驗及流行病學研究中心

Faculty of Medicine
The Chinese University of Hong Kong
5/F, School of Public Health
Prince of Wales Hospital
Shatin, N.T.
Hong Kong

31 July 2003

Secretary,
SARS Review Committee,
HK SARS Expert Committee Secretariat
Health, Welfare & Food Bureau
Room 1808, Murray Building
Garden Road
Central

Dear Mr. Luk,

Please find enclosed copies of some papers we wrote on SARS, I believe that they may add to the understanding of the SARS epidemics in Hong Kong. I hope members of your review board find it helpful in their work. I am happy to provide further information about these studies or meet with members to discuss about these studies if it is necessary.

Best regards

Prof. Joseph Lau
Director

Encl.

Sources of SARS transmission, risk and preventive factors associated with SARS transmission of undefined sources- a study of 1214 SARS cases in Hong Kong

Joseph T.F. LAU,[redacted]

Centre for Epidemiology and Biostatistics, School of Public Health, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, China

Correspondence and reprint addressed to:

Dr. Joseph T.F. LAU

Centre for Epidemiology and Biostatistics

5/F, School of Public Health, Prince of Wales Hospital

Shatin, N.T., Hong Kong

Tel: (852) 2637-6606

Fax: (852) 2645-3098

Email: jlau@cuhk.edu.hk

Word count for the abstract: 298

Word count for the main body text: 3907

ABSTRACT

Context: The sources of transmission of the Severe Acute Respiratory Syndrome (SARS) cases in Hong Kong and the effectiveness of different public health measures had not been reported.

Objectives: (1) To understand the distribution of the sources of transmission of the SARS cases in Hong Kong.; (2) To study risk and protective factors associated with SARS transmission in Hong Kong.

Setting: The general community in Hong Kong

Design: All SARS cases in Hong Kong, as of May 16, 2003, were contacted, 72% of them joined the study. They were classified into the "known sources" group and the "undefined source" group. For the latter group, a 1:2 matched case control study was conduct to study the above-mentioned preventive and risk factors.

Participants: Data from 1214 SARS cases were used for Part I of the study, 330 of which were matched with 660 controls recruited by a random telephone interview.

Main outcome measures: Sources of transmission for Objective one and whether a case or a control for Objective 2.

Results: About 30% of the studied cases did not have a well-defined source of transmission (about 20% having susceptible source and about 10% having no clue at all about the source). Hospital-related infection may account for up to 45% of all cases, secondary attack on household members accounted for another 16%. Visiting mainland China/ Singapore/ Taiwan

(OR=2.08), visiting the Prince of Wales Hospital (OR=7.14) and other hospitals/clinics (OR=3.68) and visiting the Amoy Garden (OR=7.68) were risk factors. Frequent mask use in public venues (OR=0.36), frequent hand washing (OR=0.58) and disinfecting the living quarter (OR=0.4) were significant protective factors.

Conclusions: Community-acquired infection did not make up a majority of the SARS transmissions in Hong Kong. Public health measured may have contributed substantially to the control of the epidemics in Hong Kong.

BACKGROUND

As of June 11, 2003, there were 1755 confirmed or probable SARS cases in Hong Kong (1). There are some "known" sources of SARS transmission in Hong Kong. For instance, the first major SARS outbreak occurred in the Prince of Wales Hospital in March, 2003 and 138 suspected cases were reported during March 11 to 25, 2003(2). Another major outbreak occurred in the Amoy Garden Estate around March 26, 2003 and a total of 321 residents were affected (3). Nosocomial infection also accounted for a substantial proportion of all SARS cases in Hong Kong; it was reported that a number of 381 hospital workers were affected as of May 29, 2003 (4). There are yet other possible sources of infection. For instance, some inpatients were cross-infected by some SARS patients when they were hospitalized for reasons other than SARS(5); others may have contracted the disease through known contacts with other SARS patients, including those who were household members and others that did not live with them (6). The rest of the community-acquired cases contracted the diseases via some less defined sources.

The distributions of the "known" and "undefined" sources of infection have not been reported. Such an initiative would help to assess the infectivity and modes of transmission of the virus in the community setting and provide some much needed information for effective preventive measures for further outbreaks and its containment.

There are also reports and observations that public health measures, such as wearing masks, frequent hand washing, avoidance of crowded places, disinfection of the living quarters etc. had been practiced by the majority of the Hong Kong people during the SARS outbreak (over 90%, Lau, et al. unpublished data). There were controversies about the efficacy of widespread use of masks(7) and there was no available evidence of the efficacy of mask use and the other above-mentioned means of protection. It is important to evaluate the efficacy of such measures in controlling the epidemic in Hong Kong. That would clarify what public responses should be made if we have to encounter another SARS outbreak in the future.

OBJECTIVES

The study has two objectives:

1. To delineate the distribution of different sources of transmission of the SARS cases in Hong Kong. The number of cases of "known" and "undefined" sources was determined. "Known" sources included those who were hospital workers (and thus likely to have been subjected to nosocomial infection), those who lived in the Amoy Garden Estate, those who were probable secondary cases within a household (i.e. those with another household member who had contracted SARS but had an earlier date of onset of symptoms as compared to themselves), those who were inpatients and were cross-infected by other inpatients and those who had contracted some non-household members who were known to be SARS cases before the onset of fever of the SARS patient in question. The rest can be seen as having contracted the virus via some "undefined sources".

2. For the "undefined source" group, a number of hypotheses were tested to identify relevant risk and protective factors that were associated with contracting the disease. Four hypotheses were related to visiting some places of potentially high risk.

(1). Whether visiting China or other affected areas was associated with a higher chance of contracting SARS.

(2). Whether visiting a patient in the PWH or visiting other hospitals/clinics were risk factors.

(3). Whether visiting (but not living) in Amoy Garden was a risk factor.

(4). Whether frequent visits to crowded places were associated with high risk for transmission.

The following three hypotheses were related to meeting potentially at-risk people:

(5). Whether contacting someone with fever or flu-like symptoms was a risk factor.

(6). Whether making social contacts with medical professionals was a risk factor.

(7). Whether contacting someone who had visited a hospitalized patient was a risk factor.

The other three hypotheses were related to public health preventive means.

(8). Whether frequent wearing a mask in public venues was associated with a lower risk for transmission.

(9). Whether frequent hand washing was associated with a lower risk for transmission.

(10). Whether disinfection of the living quarter was associated with a lower risk of SARS transmission.

SUBJECTS AND METHODS

Subjects

The study population comprised of all confirmed or suspected SARS cases that were reported to the Department of Health on or before May 16, 2003 (n=1690). In Hong Kong, confirmed or suspected SARS cases were defined as those with radiographic evidence of infiltrates consistent with pneumonia, and fever >38 degrees any time in the preceding two days, and at least 2 of the following symptoms: a) history of chills in the past 2 days, b) cough or breathing difficulty, c) general malaise or myalgia or d) known history of exposure(8).

Data Collection

The list of telephone numbers as well as some demographic and clinical background information of all confirmed and suspected SARS cases in Hong Kong (identified on or before May 16, 2003 (n=1690) were obtained from the Department of Health. A team of trained interviewers called all these numbers and briefed the person answering the phone about the nature of the study and obtained their informed consent to join the study. The number of SARS cases in the household was ascertained and the interviewer identified the index patient (IP) who had the earliest date of onset of fevers if the household had had more than one SARS cases. The rest of the SARS cases with later onset as compared to the IP were considered as probable secondary/tertiary cases. When a household had had two or more SARS cases with the same fever onset date (11 households), both were treated as IP rather than probable secondary cases.

A research staff member later cross-checked that the IP was in fact the one with the earliest onset of fever, in case there were more than one SARS cases in the household, by using the information of the SARS database of the Department of Health. The names of the household members were also checked against the master list to ensure that no duplicated interviews had been made for the same household.

The study was conducted between April 4, 2003 and June 10th, 2003. Of the 1690 suspected and confirmed SARS cases reported in Hong Kong as of May 16, a total of 1214 (72%) SARS cases from 996 households had been covered by the study. Of the remaining 476 reported SARS cases in Hong Kong that were not covered by this study, 140 cases (8.2%) did not have a correct phone number, 163 (9.6%) could not be contacted after at least 5 different attempts, 163 cases (9.6%) refused to participate in the study and 10 cases (0.6%) were either not in Hong Kong or could not communicate in Chinese or English.

Study Design

The study is part of a project that also includes an investigation of the secondary attack rate of household members (probable secondary infection). For the first part of this study, the IP cases were asked whether they were hospital workers, whether they were inpatients before contracting SARS and whether they lived in the Amoy Garden. For those who did not belong to these three groups, they were further asked whether they had contacted a SARS patient within a 10-day period before his/her onset of fever. These four types of SARS cases were classified into the "known sources" group. The rest of the IP cases were classified into the "undefined source" group. In the second part of the study, a 1:2 matched case control study was conducted for the "undefined source" group to identify risk and preventive factors associated with SARS transmission in the community setting.

Only adults of age 16 or above were included in the case control study (17 out of 347 cases in the "undefined source" group were hence removed from the analysis). Potential geographically related risk factors studied included whether he/she had visited (but not lived in) the Amoy Garden, whether he/she had visited the PWH, whether he/she had visited other hospitals or clinics and the frequency of visiting crowded places within a reference period of 10 days before the case's onset of fever. Other risk factors were related to contacts made with different categories of people during the same reference time period, including medical personnels, hospital visitors, someone with flu' like symptoms (who were not SARS cases). A number of protective factors that are related to relevant public health measures, including the frequency of using face mask when present in public venues, the frequency of washing hands per day and whether disinfecting one's living quarter during the same reference period. The same questions were asked to the control group, which was recruited by a random telephone survey. Members of the control group were matched for age and gender. The reference period for the questions was set to be the same as that of the matched case. For example, if a case had had his/her onset of fever on April 15, the reference period for the above-mentioned questions would be April 5th to April 15^{th} (10 days before the case's onset of fever), which is the same for both the case and its two matched controls. Random telephone numbers were selected from the up-to-date local telephone directories. The interviews were carried out in the evening to avoid over-representation of people who were not working in daytime. At least 3 calls were made before an unanswered call is considered as a "non-contact". Informed consent was obtained before the interviews were conducted.

Almost all cases were interviewed within 14 to 28 days after their onset of fever and the control group was interviewed accordingly. When a case was not able to answer the questionnaire, a proxy, who was "most familiar with the family situations", was interviewed.

Data Analyses

The frequency distribution according to the sources and risk factors was presented. For the case control study, odds ratios were firstly examined by using univariate logistic regression models. The univariately significant variables were then entered as input for the multivariate stepwise conditional logistic regression analysis. P-values less than 0.05 were considered as statistically significant. SPSS for Windows Release 11.0.1 (SPSS Inc., Chicago, USA) was used to analyze the data.

RESULTS

Number of cases of "known" sources of transmission

Out of the 1214 suspected or confirmed SARS cases covered by this study, 22 questionnaires (1.8%) were incomplete, and did not allow us to classify the respondents into groups of different sources of transmission. The rest of the cases (n=1192) were being analyzed by this study. From Table 1, 192 (16.1%) were probable cases of secondary/tertiary household transmission (one having another household member who had also contracted SARS but had had fever onset occurring before him/her) and 317 of these cases (26.6%) were hospital workers; 170 (14.3%) lived in the Amoy Garden; 58 (4.9%) were inpatients before contracting the virus (and were hence cross-infected). There are 727 cases belonging to one of the four above-mentioned categories (61% of the 1192 cases). Another 240 (20.1%) had contracted a SARS case within a 10-day period before his/her date of onset of fever. There were still 437 cases (29.1%) left unaccountable by the "known" sources (the "undefined source" group) and they are subjected to the case control analysis. After excluding 17 cases aged below 16 years, these 347 cases were used for the case control study.

Univariate case control analysis

Amongst the 330 cases of "undefined source", 155 were male and 168 were female ($p>0.05$, chi-square test). The mean age of the case group was 47.1 for both the male and female cases (SD=18.8 and 19.9 respectively, $p>0.05$, t test). The percentage of "undefined source" cases out of all cases within three periods of the epidemic (before March 25th, 2003, between March 26th and April 10th and after April 10th) were 24.2%, 36.1% and 43.5% respectively ($p<0.001$, Chi-square for trend test).

It can be seen that members of the case group were more likely to have visited mainland China (12.7 vs. 6.5%, $p<0.005$) or to have visited mainland China, Singapore or Taiwan (13.3 vs. 6.7%, $p<0.005$). Similarly, they were also more likely to have visited the Amoy Garden (15% vs. 2%, OR=9.10, $p<0.005$) (keeping in mind that those who lived in the Amoy Garden had already been "removed" from the analysis); they were more likely to have visited the Prince of Wales Hospital (3.6 vs. 0.5%, OR=8.27, $p<0.005$) or other hospitals or clinics (40.7 vs. 17.0, OR=3.36, $p<0.005$). A total of 212 cases of the "undefined source" group had visited at least one of the above-mentioned categories of places (Table 2). Frequency of visiting crowded places was, however, not of statistical significance in the univariate analysis (21.91 vs. 20.8%, OR=1.07, $p>0.05$).

Members of the case and control groups were not statistically different in the percentages having contacted someone with flu' like symptoms (keeping in mind that those having made contacts with SARS patients were already removed, 9.0 vs. 6.4%, OR=1.42, $p>0.05$). The two groups were also not different in the likelihood of socially contacting someone who had visited a hospital (8.2 vs. 5.2%, OR=1.66, $p>0.05$) or having made social contacts with some medical personnels (7.6% vs. 8.6%, OR=0.87, $p>0.05$). It is also not true (keeping in mind that the Amoy Garden cases had already been removed from the analysis) that the cases were more likely to have a known SARS case in the same housing estate where they lived (such data was made available by the government after April 12, 2003(9).

Furthermore, matching for the reference time period (see Subject and Method), members of the case group were much less likely than members of the control group to have been frequently wearing a face mask in public venues (27.9 vs. 58.7%, OR=0.36, $p<0.005$), to have been washing their hands for more than 10 times a day (18.4 vs. 33.7 % OR=0.44, p<0.005) and to have disinfected their living quarter thoroughly (46.6 vs. 74.5%, OR=0.30, p<0.005).

Multivariate analysis

Using all the variables that were significant in the above-mentioned analysis as input for the multivariate stepwise conditional logistic regression analysis, the results show that having visited mainland China/Singapore/Taiwan (OR=2.08, p=0.009, see Table 2), having visited the Amoy Garden (OR=7.68, p<0.001), having visited the Prince of Wales Hospital (OR=7.14, p=0.009), having visited other hospitals or clinics (OR=3.68, p<0.001) during the reference period were significant risk factors. On the other hand, having been using a mask frequently in public places (OR=0.36, p<0.001), having washed one's hands for more than 10 times a day (OR=0.58, p=0.008) and having disinfected the living quarters thoroughly (OR=0.40, p<0.001) during the reference period were significant protective factors (Table 2).

Number of cases remaining "undefined" after removing those having visited places of high risk.

After removing those cases who could be seen as susceptible for having contracting the SARS disease as a result of visiting the Amoy Garden, the Prince of Wales Hospital or other hospitals or mainland China/Singapore/Taiwan (212 cases of the 330 cases), 118 cases remained yet "undefined". They were likely to be community-acquired cases of "unknown" sources of transmission. When univariate and multivariate conditional logistic regression analyses were repeated for this sample (cases:118 and controls: 226), similar results are obtained. The three public health measures variables: frequent mask use in public places (adjusted OR=0.36, p<0.001), washing hands for more than 10 times a day (adjusted

OR=0.44, p=0.008) and disinfecting the living quarter thoroughly (adjusted OR=0.36, p<0.001) remained to be significant protective factors.

DISCUSSION

A summary can be made that basing on the 1192 cases analyzed by this study, about 16.1% of them were probable cases of secondary or tertiary transmission occurring within the household, 26.6% of them were nosocomial infection of hospital workers, 14.3% were Amoy Garden cases and 4.9% were cross-infected inpatients, 20.1% might have contracted SARS in contact with some SARS patients who were non-household members (some may be in hospitals and some may be in community settings). Another 18.6% might be related to visiting Amoy Garden, hospitals/clinics, some affected countries (29.1%-9.9%, see Table 1), therefore leaving 9.9% to be community-acquired cases of an unknown source. From another perspective, if we add up all the cases that were related to Amoy Garden (lived there or having visited there), the percentage would be 18.5% (221/1192). Similarly, if we add all categories that were related to hospitals (hospital workers, inpatients and visitors), the percentage that was hospital-related would be 44.5%(530/1192).

The percentage of unknown community-acquired infection of this study (9.9%) was similar to the 8.5% figure announced by the Department of Health, Hong Kong(10). Compared to the high infectivity in the hospital setting, it can be considered as relatively low. (Even taking the 4.3% who had visited the Amoy Garden into account, the percentage was still relatively low). It suggests that it is absolutely essential to prevent hospital outbreaks to occur and to cut the link between hospital cases and transmissions into the community. As seen from this study, even after excluding hospital workers and those having contacted a SARS case (including those visiting some hospitalized SARS patients), frequent hospital visitors (they were likely to be medical consultation seekers) were still responsible for 44.2% of all the 330 "undefined" transmissions studied. From another study on household transmission, it was also seen that hospital visits to see the household member who was the index person within the household initially contracting the virus was a significant risk factor predicting household secondary infection and in fact, about 16% of all these hospital visitors contracted the disease (Lau, et al. unpublished data). Therefore, the severity of future outbreaks, if any, would depend very much on the ability of the hospital system in controlling hospital cross infection and infection of visitors.

Visits to mainland China, or to mainland China/Singapore/Taiwan (only one visited Singapore and one visited Taiwan) were associated with SARS transmission, even after adjusting for other variables of the multivariate conditional logistic regression model. It is saying that cross-border transmission had played a role in the epidemic, though the absolute percentage may not be very high among the 1192 cases (3.61% or 43/1192), it may still be substantial among the "undefined source" group (13.3%). Without a case control design, it could not be established whether this 13.3% was associated with an inflated risk. Cross-border communication and prevention, such as those having been set in place (thermal screening and health declaration) therefore needs to be enforced strictly and consistently.

Those variables related to social contacts made with medical personnels or hospital visitors and those with flu' like symptoms and as well, those living in a housing estate that reported a SARS case were not of statistical significance. These should be interpreted with caution. On one hand, it says that there is no reason to stigmatize these individuals. On the other, the results may have been confounded by the fact that all those who had contacted a SARS cases were excluded from the analysis, which confined itself to study of cases whose source of transmission was less defined. It is, however, useful to confirm that these variables could not account for transmissions of the "undefined source" cases.

There is also no evidence to show that frequent visits to crowded places were associated with a higher likelihood of community-acquired infection. The finding may remove some panics that arose during the epidemic and daily life need not be interfered as much as it had been. Hong Kong had been a densely populated city and had a large number of SARS cases. The likelihood of community-acquired in other cities that are less populated and had had less SARS cases should be much lower than that of Hong Kong.

As seen, visiting the Amoy Garden was a risk factor. However, Amoy Garden might be the only special case in the world where a large-scale SARS outbreak was attributable to environment contamination. The findings has however, also to be interpreted with care as over 90% of the general public had been wearing a face mask when appearing in public places and over 85% of them had been avoiding to visit public places when the epidemic occurred in Hong Kong (Lau, et al. unpublished data).

For the first time, we have some empirical evidence to suggest that wearing a face-mask frequently in public places, frequent hand-washing and disinfecting one's living quarter were effective public health measures to reduce the risk of transmission (odds ratios: 0.53-0.27). There had been a controversy about the effectiveness of mask use (7). From another study the prevalence of these three public health preventive public health measures increased significantly from 21 March 2003 to 1 April 2003 (i.e. mask-wearing from 11.5 to 84.3% and frequent hand washing from 61.5 to 95.1%, and home disinfection from 36.4% on 24 March

2003 to 80% on 11 April 2003) (Lau, et al. unpublished data). These practices had therefore played an essential role in limiting the spread of the virus in the community in Hong Kong.

The finding that disinfecting the living quarter is a strong protective factor has a particular relevance. Keeping in mind that probable secondary cases had already been removed from the analysis, it is not referring to the effects that disinfecting the quarter reduced the chance of secondary infection. Environmental contamination had been reported in the Amoy Garden and there is no reason to believe that environmental contamination could not have occurred in other places. Such infections that were related to contamination might be of a small scale and had not been noticed. The findings therefore suggest that besides the droplet theory, the formites theory could not be dismissed. It also has a strong public health implication in preventing the spread of the virus in a community setting.

The study has a few limitations. Firstly, only about 72% of all cases were included by the study (excluding the cases whose contact numbers were incorrect or not available, about 78% of the rest were covered and the refusal rate was about 10%). It is, however, the only study of the type and had had a reasonable large sample size. Secondly, data were collected retrospectively. Most of the data were, however, collected from the cases within one month after his onset of fever. Since contracting the disease is a major life event for the patient and his/her family, they should be able to recall whether such factual and benchmark behaviors had been practiced. The study also has strength of matching for age, gender and the reference time of the behaviors in question, so that both the case and control in a pair were referring to relevant behaviors that occurred within the same 10-day period before the date of onset of fever of the case. Thirdly, a number of patients were unable to answer the questions and a household member who was "most familiar with the household situation" was invited to serve as a proxy. The responses obtained from these informants were compared to those obtained from the patients themselves and no statistical significance was obtained ($p = 0.199$ to 0.854) to all variables, except the variable on whether visiting the Amoy Garden ($p<0.05$).

One particular strength of the study in its evaluation of the three public health measures is that transmissions due to various sources of infection had been removed as much as possible. The study is the one of the type on the topic and should have added insights to the likelihood and prevention of community acquired transmission of SARS.

Acknowledgement

This study is funded by The Chinese University of Hong Kong.

REFERENCES

1. World Health Organization. Cumulative Number of Reported Probable Cases of SARS.http://www.who.int/csr/sars/country/2003_07_09/en/, accessed on July 11, 2003.
2. Lee N, Hui D, Wu A, Chan P, Cameron P, Joynt GM, et al. A major outbreak of severe acute respiratory syndrome in Hong Kong. N Engl J Med 2003;348(20):1986-94.
3. Health, Welfare and Food Bureau. Health, Welfare & Food Bureau SARS Bulletin (18 April 2003).http://www.info.gov.hk/dh/diseases/ap/eng/bulletin0418.htm, accessed on July 11, 2003.
4. Government Information Centre of Hong Kong. Situation report on Severe Acute Respiratory Syndrome.http://www.info.gov.hk/dh/new/bulletin/bullet.htm, accessed on July 11, 2003.
5. Tan YM, Chow PK, Soo KC. Severe acute respiratory syndrome: clinical outcome after inpatient outbreak of SARS in Singapore. Bmj 2003;326(7403):1394.
6. Tomlinson B, Cockram C. SARS: experience at Prince of Wales Hospital, Hong Kong. Lancet 2003;361(9368):1486-7.
7. Hong Kong Department of Health. Wearing Mask.http://www.info.gov.hk/dh/diseases/ap/eng/facemask.htm, Accessed on July 14, 2003.
8. Hong Kong Hospital Authority. Diagnosis & Reporting.http://www.ha.org.hk/sars/ps/information/diagnosis_n_report.htm, Accessed on July 11, 2003.
9. Hong Kong Department of Health. List of buildings with SARS cases released.http://www.info.gov.hk/dh/new/2003/03-04-12e2.htm, Accessed on July 15, 2003.
10. Lipsitch M, Cohen T, Cooper B, Robins JM, Ma S, James L, et al. Transmission dynamics and control of severe acute respiratory syndrome. Science 2003;300(5627):1966-70.

Table 1 Distribution of 1214 SARS cases covered by the study

	n	Percentage
Incomplete information	22	-
Complete information	1192	100**
1. Known sources (any of 1.1 to 1.4)	727	61.0
1.1 Probable secondary/tertiary household infection	192	16.1
1.2 Hospital care workers	317	26.6
1.3 Amoy Garden residents	170	14.3
1.4 Inpatients	58	4.9
2. Not belong to 1.1-1.4 but had contacted SARS patient/s within 14 days beforeonset of fever	240	20.1
3. Community-acquired cases of sources (not belong to 1 and 2)	347	29.1
3.1 had visited Amoy Garden*	51	4.3
3.2 had visited PWH*	12	1.0
3.3 had visited other hospitals/clinics*	143	12.0
3.4 had visited an affected country*	43	3.6
3.5 None of 3.1 to 3.4*	118	9.9

*: Not including cases aged below 16 years; **: Caculated based on completed data.

Table 2 Preventive measures and risk factors reported by cases and controls

Factors	Case (n=330)	Control (n=660)	Univariate OR (95% CI)	Multivariate OR (95% CI)	P value†
% visited mainland China/Singapore/ Taiwan (Reference=no)	13.3	6.7	2.15(1.38-3.35)***	2.08(1.20-3.60)	0.009
% visited mainland China? (Reference=no)	12.7	6.5	2.09(1.33-3.27)***	N.S.	0.001
% visited PWH? (Reference=no)	3.6	0.5	8.27(2.32-29.49)***	7.14(1.64-31.06)	0.009
% visited other hospitals/clinics (Reference=no)	40.7	17.0	3.36(2.49-4.54)***	3.68(2.53-5.36)	<0.001
% visited Amoy Garden (Reference=no)	15.5	2.0	9.10(4.87-17.00)***	7.68(3.80-15.53)	<0.001
% visited crowded places frequently (Reference=occasionally/seldom/no)	21.9	20.8	1.07(0.76-1.50) N.S.	-	-
% contacted someone with fever or flu (Reference=no)	9.0	6.4	1.42(0.87-2.32) N.S.	-	-
% social contact with someone who visited a patient in a hospital (Reference=no)	8.2	5.2	1.66(0.96-2.85) N.S.	-	-
% social contact with medical personnel (Reference=no)	7.6	8.6	0.87(0.52-1.44) N.S.	-	-
% had a SARS case in the housing estate (Reference=no)	6.6	8.5	0.76(0.44-1.31) N.S.	-	-
% disinfected the living quarters thoroughly (Reference=no)	46.6	74.5	0.30(0.23-0.39)***	0.40(0.29-0.57)	<0.001
Wore a mask in public places frequently (Reference=occasionally /seldom/no)	27.9	58.7	0.27(0.20-0.37)***	0.36(0.25-0.52)	<0.001
Washed hands 11 or more times per day (Reference: 1-10 times/day)	18.4	33.7	0.44(0.31-0.63)***	0.58(0.38-0.87)	0.008

N.S.: Not significant; *: $p<0.05$; **: $p<0.01$; ***: $P<0.005$;
†: p values for multivariate OR;
- Not used by the multivariate analyses.
The reference time period is the 10 days before the date of the case's onset of fever.

THE ATTACK RATES AND ASSOCIATED RISK FACTORS OF PROBABLE SECONDARY INFECTIONS WITHIN HOUSEHOLDS OF SARS PATIENTS IN HONG KONG:

Joseph T.F. Lau, Ph.D.[1]
[redacted], BSc.[1]
[redacted], Sc.D.[1]
[redacted] M.A.[1]
[redacted] M.Phil[1]
[redacted], MD[2]
[redacted] MD[3]
[redacted], MD[4]

[1]Centre for Epidemiology and Biostatistics,
School of Public Health, Faculty of Medicine
The Chinese University of Hong Kong
[2] Department of Health, Hong Kong SAR Government
[3]Department of Community and Family Medicine, The Chinese University of Hong Kong
[4] World Health Organization

Total page count: 21 (including cover page, citations and tables)
Abstract word count: 231
Total word count: 2948 (excluding abstract and references, and tables)
Keywords: SARS, secondary infections, epidemiology, Hong Kong

<u>Address for correspondence and reprint requests:</u>

Dr. Joseph T. F. Lau, Director
Centre for Biostatistics and Epidemiology
Faculty of Medicine, The Chinese University of Hong Kong
5/F, School of Public Health, Prince of Wales Hospital,
Shatin, NT; Hong Kong SAR
Tel (852) 2637-6606
Fax (852) 2645-3098
Email:jlau@cuhk.edu.hk

ABSTRACT

Background: It has been shown that Severe Acute Respiratory Syndrome (SARS) is highly infectious in hospital settings yet, the attack rates of SARS in household settings and relevant risk factors have not been reported.

Methods: Information of 1214 SARS confirmed and supsected SARS cases (72% of all cases as of as of May 16, 2003) and their household members were obtained. The attack rates at household and household member's levels, stratified by two phases of the epidemic and background of the index case were calculated. A case-control analysis was also conducted to identify risk factors associated with probable secondary infection.

Findings

Overall, probable secondary infection occurred in 14.9% (22.1% vs. 11% in earlier and later phases) of all households (excluding single households) and 8% of all household members studied. The rates were higher in the early phase (11.7% vs. 5.9%). Households of health care workers were less likely to be affected. Besides, risk factors identified by the stepwise multivariate logistic regression analysis also included duration of home stay between fever onset and hospitalization, hospital visit to see the index SARS patient (and mask use during the visit) and frequency of close contacts.

Interpretation

SARS transmission at household level is not negligible in Hong Kong. Transmission rates could be reduced as awareness increases, by early detection and hospitalization, avoidance of hospital visits and avoidance of close contact with household members showing flu-like symptoms.

Introduction

The first large scale Severe Acute Respiratory Syndrome (SARS) outbreak occurred in the Prince of Wales Hospital (PWH) in Hong Kong around March 11th, 2003.[1,2] It was followed by a large-scale community outbreak in the Amoy Gardens estate which reported a total of 321 SARS cases as of April 15, 2003, of which 41·0% were Block E residents.[3] As of May 31, 2003, a total of 1739 suspected or confirmed SARS cases were reported in Hong Kong, out of which 384 were hospital workers (22·1%) and about 321 were residents of the Amoy Gardens.[4] (see Figure 1)

In the clinical setting, there has been evidence of a very high attack rate of the SARS virus.[5] However, there are little, if any, data describing the attack rates in general community settings. The first objective of the study is to estimate the household attack rates (HAR) and the household member attack rates (HMAR) for different categories of SARS patients. The second objective is to investigate risk factors that are associated with HAR and HMAR

Methods

Study population

The study population comprised of all confirmed or suspected SARS cases that were reported to the Department of Health on or before May 16, 2003 (n=1690), as well as all their household members (including kin, non-kin and domestic helpers). In Hong Kong, confirmed or suspected SARS cases were defined as those with radiographic evidence of infiltrates consistent with pneumonia, and fever >38 degrees any time in the preceding two days, and at least 2 of the following symptoms: a) history of chills in the past 2 days, b) cough or breathing difficulty, c) general malaise or myalgia or d) known history of exposure.[6]

In this study, an index person (IP) is defined as the SARS case that had the earliest date of onset of fever within a household. Household members(s) that had the onset of symptoms at a date later than that of the IP is/are considered to be probable secondary (or tertiary) cases. Three of these probable secondary/tertiary cases were hospital workers who may have contracted SARS in the hospital setting and were hence excluded from the analysis.

Data collection

The list of telephone numbers as well as some demographic and clinical background information of all confirmed and suspected SARS cases in Hong Kong (identified on or before May 16, 2003 (n=1690)) were obtained from the Department of Health. A team of trained interviewers called these numbers and briefed the person answering the phone about the nature of the study and obtained their informed consent to join the study. He/she then identified the IP who had the earliest date of onset of fevers and confirmed to ensure that the households had not been interviewed twice. When a household had had two or more SARS cases with the same fever onset date (11 households), one of them was randomly selected as the IP. Respondents were then requested to hand the telephone over to the household member (who may or may not be the IP) who was most familiar with the household situation, to serve as the informant. Care was taken to ensure that the interview occurred at least after 14 days after the IP's onset of symptoms in order to exceed the maximum incubation period of 10 days.

A research staff member later cross-checked that the IP named by the informant was in fact the one with the earliest onset of fever, in case there were more than one SARS cases in the household, by using the information of the eSARS database of the Department of Health. The names of the household members provided by the informants were also checked against the master list to ensure that no duplicated interviews had been made for the same household.

The study was conducted between April 4, 2003 and June 10th, 2003. Of the 1690 suspected and confirmed SARS cases reported in Hong Kong as of May 16, a total of 1214 (72%) SARS cases had been covered by the study (see Figure 1). The 1214 SARS cases came from 996 households (the 881 households were analyzed and 115 single households which were excluded from the analysis). Of the remaining 476 reported SARS cases in Hong Kong that were not covered by this study, 140 cases (8·2%) did not have a correct phone number, 163 (9·6%) could not be contacted after at least 5 different attempts, 163 cases (9·6%) refused to participate in the study and 10 cases (0·6%) were not in Hong Kong or could not communicate in Chinese or English.

Questionnaire

The study questionnaire collected the following information:

1. Information about the index patient, including age, gender, occupation, date of admission, hospital of admission, date of onset of fever, whether he/she resides in the Amoy Gardens (and block number).

2. Household information—including all household members' names, ages, gender and relationship with the IP, and to state whether they were hospital workers.

3. Information about any "probable secondary SARS infection" among household members was collected.

4. Data regarding hospital visits to see the IP were collected.

5. Data regarding contact between individual household members and the IP were collected (whether any of the household members had been sharing a room or sharing a bed with the IP, who was the IP's primary caretaker, whether other household members had dined with the IP, if they had been within 1 meter of the IP, and if they had been coughed at by the IP (and if so, the frequency of each of these behaviors, categorized as never, seldom, occasionally and frequently).

Study Design

The HAR was defined as the number of household with at least one probable secondary SARS case divided by the total number of IP's households. The HMAR was defined as the total number of probable secondary SARS cases of all relevant IP's households divided by the number of household members (not including the IP) of all relevant IP's households.

Two analyses were performed in order to identify risk factors that were associated with HAR and HMAR. In the first analysis, households that had at least one "probable secondary infection" were compared with those households which had no "probable secondary infections" in a number of risk factors. In order to control for any period effects, a dummy variable was created to represent the 2 time periods (before March 25th, 2003, and on or after March 25th, 2003). March 25th corresponds to the beginning of the Amoy Gardens outbreak, after which time the public awareness of SARS was greatly heightened [7]. It was also shown that the average number of secondary cases from one SARS-infected individual declined greatly from the 2·7 in the initial part of the epidemic to 0·9 average secondary cases after March 25th, 2003.[8]

The second analysis used a case-control design that compared individual family members who were probable secondary SARS cases with those who were not. In order to avoid ambiguities arising from distinguishing secondary and tertiary infections, only the probable secondary cases whose onset of fever was closest to that of the IP were used as a case in this analysis, if there were multiple SARS cases in the household. In addition to the variables examined in the above-mentioned household level analyses, this analysis also examined the frequency of close contacts between the case/control and the IP (e.g. dining together, sharing a bedroom, etc., see Questionnaire).

Statistical analyses

The HAR and HMAR were calculated separately for the 4 groups of IP (hospital workers, Amoy Block E and other block residents and other community members) and 95% confidence intervals (CI) were also derived.

Univariate odds ratios and p-values from chi-square test were obtained. Stepwise multivariate logistic regression methods, using candidate variables that had at least a marginally significant association in the univariate analysis ($p<0\cdot10$) was conducted in order to obtain factors independently associated with HAR and HMAR. SPSS Version 11 was used for all analyses.

Results

Background characteristics of the index patients

The background characteristics of the IP are summarized in Table 1.

HAR

The overall HAR, as defined, was 14·9% (95% confidence interval (CI)=12·6% - 17·4%) for all the households of the 881 IP studied. The HAR was much higher for households of those IP whose onset of fever occurred before March 25,2003 (the earlier onset group) than those with onset of fever occurred on or after that date (the later onset group) (22·4% vs. 11·0%, OR=0·43, p=0·001). The Amoy Block E households had had the highest HAR (38·9%), followed by those living in the other blocks of the Amoy Gardens (19·6%) and households of the "other community member" group (18·3%). The households with IP who were health care workers had had the lowest HAR (3·8%). Moreover, the HAR were higher for the earlier onset group as compared to the later onset group for all the 4 strata (see Table 2).

HMAR

Among all 2139 household members of the 881 IP, 8% (n=188, 95% CI: 7·0% to 9·2%) were probable secondary cases. The HMAR for the hospital care worker group, the other community group, the Amoy non-Block E group and the Amoy Block E group were 1·9%, 9·8%, 11% and 24·4% respectively. Similar period effects were observed: the odds ratios for comparing the two fever onset groups (on/after vs before March 25, 2003) were 0·15 (hospital worker group p=0·004), 0·41 (other community group, p<0·001), and 0·29 (Amoy non-E group, p=0·002). For Amoy Block E respondents, the figures for the earlier and later onset groups were 37·1% and 17·7% respectively (p=0·058) (see Table 2).

Factors associated with HAR

While gender of IP was not a significant factor, older age of IP (OR= 1·57-3·77), type of IP (OR=5·74 to 16·35), longer duration home stay between fever onset and hospitalization (OR= 1·76 to 3·91), IP being visited by any household member(s) (OR=2·03), date onset fever of IP (later vs earlier onset groups, OR=0·43) were all univariately associated with HAR (Table 3). Disinfection of the living quarter after the IP's onset of fever was, however, not a significant factor (p=0·88). All of these univariately significant variables, except age were statistically significant in the multivariate stepwise logistic regression (Table 4).

Factors associated with HMAR

Similar to the case of "probable secondary infection" at the household level (HAR), type of IP (OR= 5·48 to 16·99, Table 5), IP being visited by a family member (OR=2·65), longer duration of IP's home stay (OR=1·72 and 3·18) and IP's date onset of fever (later versus earlier onset date, OR=0·48) were univariately significant factors distinguishing between the case group and the control group. Besides, if both the household member and the IP were not wearing a mask during the hospital visit, the risk for SARS transmission would be largely enhanced (OR=4·16, Table 5). Univariately, variables related to close contacts with the IP were also significantly associated with HMAR. These include whether the subject was the main care-giver of the IP (OR=2·47), whether the subject was sharing a room or a bed with the IP (OR=1·66 and 3·74), frequency of dining together with the IP (OR=1·90 and 3·82 respectively for those having dined 5-10 times and more than 10 times during the period between onset of fever of IP and his/her hospital admission) and frequency of being coughed at by the IP within 1 meter (OR = 1·81 and 2·47 respectively for responses of "occasionally" and "frequently").

Multivariately, the type of IP (hospital workers, other community workers etc.) was associated with HMAR and the directions are the same as the univariate analyses (Table 6). Besides, those household members who visited the IP but both the IP and himself/herself were not using a mask were more likely to have contracted SARS, when compared to those who had not visited the IP (OR=3·12, Table 6). Those household members who had had occasional or frequent close contacts of 1 meter or less with the IP were more likely than other household members to belong to the case group (OR=2·14 and 2·30, Table 6). The cases were also less likely to have the IP's onset of fever occurring on/after March 25, 2003, as compared to the control group (OR=0·51).

Discussion

Of approximately 72% of SARS cases in Hong Kong (as of May 16, 2003) that were covered by this investigation, about 15% of all IP's households and 8% of all members of these households had contracted SARS. The SARS attack rates were thereby not negligible. The HAR and HMAR were both much higher in the initial phase of the epidemic (before March 25th, 2003).[7] The quarantine policy was implemented for the first time only on March 31st for the Amoy Gardens residents.[9] The median home stay was therefore longer for earlier onset SARS cases (4 days) than the later ones (2 days). Between the first large scale outbreak which occurred around March 12, 2003 and the March 25, 2003, very little knowledge about the disease was available to the public and hence minimal prevention measures against secondary infections were being practiced by household members.[7]

The HAR and HMAR for households of hospital care workers were much lower than those of other types of households, even after controlling for other variables that were significant in the multivariate models. These findings suggest that with a greater awareness and proper preventive measures, secondary attacks of SARS among household members may be avoided.

The attack rates for the Amoy Block E households were much higher than those households of other blocks (for later onset households, HAR: 36% versus 13·4%; HMAR: 20·8% versus 7·7%). On the other hand, the rates of the Amoy non- Block E households were about the same as those of the "other community group" (for later onset households, HAR: 13·4% versus 13·1%; HMAR: 7·7% versus 7·2%). The high rates in Block E are likely to have resulted from environmental contamination. These data support the findings of the WHO investigation team that environmental contamination was responsible for many of the infections in the Block E, but not in other blocks of the Amoy Garden (as the non-Block E rates were largely similar to those of the households in other communities).

Visiting the IP is another independent risk factor. Among all such household members who were visitors, 16·5% (51/310) contracted SARS (20·3% and 8·2%, respectively for the earlier and later onset groups). The role of hospital visitors may have played an important part of the epidemic in Hong Kong. For instance, the source person of the Amoy Gardens infection was a hospital visitor. Consistent and explicit visiting policies should be implemented. The results also showed that the risk would be increased when both the SARS patients and the visitors were not wearing a mask. Therefore, proper personal protection equipment should be required for all visitors of SARS patients.

A longer period of exposure to the risk of secondary infection would increase the chance for household members to contracting SARS. Clear public health messages should be desseminated to the public, that medical consultations and prevention measures should be sought immediately after development of any flu' like symptoms. A good surveillance system should also be able to reduce this duration of home stay of the SARS patients substantially.

The frequency of close contact is another important risk factor for HMAR. Together with the significance of the variable of IP's duration of home stay, it is suggesting the viral load is important in determining whether a secondary infection occurs. It is consistent with the theory of droplet transmission and do not lend too much evidence to the fomite theory. This is consistent with our findings that HAR was not significantly associated with thorough disinfection of the living quarters.

The study has a few limitations. Firstly, there is no way to confirm that the "probable secondary infection" of household members actually came from the IP. Nevertheless, infection via environmental contamination has not been implicated as large source of SARS except in among Amoy Block E residents. Moreover, possible nosocomial infections were also eliminated in the analysis. The possibility of household members contracting the SARS virus outside the home is hence very small. Secondly, 44·6% of the time, information was provided by the proxy (393 out of 881households). Since these proxies were the household members that were the most familiar with the household situation and since SARS had been a major concern, the data should be reliable. Furthermore, the names of the probable secondary cases provided by the informant respondent were also cross-checked against the master list of the Department of Health for quality control purpose. Even though recall bias may be another potential problem, almost all of the interviews were made within 3 weeks after the IP's onset of fever and given the extremely unusual nature of SARS, respondents should have been able to recall the requested information in a reliable manner. Finally, the study was not able to cover all SARS patients in Hong Kong but after eliminating incorrect or unavailable contact numbers, 78·3% of all SARS patients had been covered by this study, and the refusal rate was moderate (10·5%).

The study, being the only large study to the authors' knowledge investigating SARS transmission in the community setting, allows us to have a better understanding of the infectivity, modes of transmission and prevention of SARS in a community setting. It also gives insight into the prevention of secondary SARS infection within the household.

Acknowledgements:The authors would like to express their appreciation to the study participants, the Chinese University medical students and volunteers who conducted the interviews and Dr. MK Tam of Hong Kong's Department of Health for her assistance in the project. Funding was provided by internal funding from the Department of Medicine, The Chinese University of Medicine

REFERENCES

1 World Health Organization. WHO issues a global alert of cases of atypical pneumonia: Cases of severe respiratory illness may spread to hospital staff. Geneva: World Health Organization, March 12, 2003. www.who.int/mediacentre/releases/2003/pr22/en/print.html (accessed May 1, 2003).

2 Lee N, Hui D, Wu A, Chan P, Cameron P, et al: A major outbreak of severe acute respiratory syndrome in Hong Kong. *N Engl J Med* 2003;**348**:1986-94.

3 Hong Kong Department of Health. Hong Kong: Health, Welfare & Food Bureau SARS Bulletin. www.info.gov.hk/dh/diseases/ap/eng/bulletin0418.htm (accessed May 15, 2003)

4 Hong Kong Government. Latest figures on Severe Acute Respiratory Syndrome (as of May 31st 2003). Hong Kong Government, May 31, 2003. www.info.gov.hk/dh/diseases/ap/eng/infected.htm (Accessed June 3, 2003)

5 Hong Kong Government. Latest figures on Severe Acute Respiratory Syndrome (as of June 1st 2003) Hong Kong Government, June 1, 2003. www.info.gov.hk/dh/diseases/ap/eng/infected.htm (Accessed June 3, 2003).

6 Hong Kong Hospital Authority. HA information on Severe Acute Respiratory Syndrome. Hong Kong: Hong Kong Hospital Authority, April 22, 2003, www.ha.org.hk/sars/ps/information/diagnosis_n_report.htm (Accessed June 17, 2003)

7 Lau J, [redacted] Monitoring community responses to the SARS epidemic in Hong Kong– from Day 10 to Day 62. 2003. In review

8 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**:1961-6.

9 Hong Kong Department of Health. Household contacts of AP patients order to stay home. Hong Kong Government, April 30, 2003. www.info.gov.hk/gia/general/200304/10/0410248.htm (Accessed June 30, 2003)

Table 1. Background characteristics of the Index Patient (IP)

	n	%
Gender		
Male	400	45·4%
Female	481	54·6%
Age[1]		
<18	44	5·1%
18-30	239	27·8%
31-40	197	22·9%
41-50	165	19·2%
51-60	76	8·8%
61+	138	16·1%
Education level[2]		
No education	60	7·1%
Primary	152	17·9%
F1-F3	123	14·5%
F4-F5	208	24·5%
F6-F7	44	5·2%
University or above	263	31·0%
Type of IP		
Health care worker	267	30·3%
Amoy Gardens Block E residents	36	4·1%
Amoy Gardens other block residents	107	12·1%
Other community member	471	53·5%
Duration IP stayed home between fever onset and hospitalization[4]		
≤2 days	440	50·1%
3-5 days	268	30·5%
≥6 days	171	19·5%
IP visited by any household member during hospitalization		
No	682	77·4%
Yes	199	22·6%
Date of IP's fever onset[3]		
Before March 25	299	34·0%
On or after March 25	581	66·0%

[1] 22 missing individuals [2] 31 missing individuals [3] 1 missing individual [4] 2 missing individual

Table 2. Household Attack Rates (HAR) and Household Member Attack Rates (HMAR) for different categories of Index Patient

Type of Index Patient	Date IP's fever onset < March 25, 2003	≥ March 25, 2003	Overall	Odds ratio (95% CI)[1]	*Chi-square P-value*
HAR					
Hospital workers	n=114 7·0% (3·1% - 13·4%)	n=153 1·3% (0·2% - 4·6%)	n=267 3·8% (1·8% - 6·8%)	0·18 (0·02, 0·91)[2]	0·021
Other community members	n=148 29·1% (21·9% -37·1%)	n=322 13·4% (9·8% - 17·6%)	n=471 18·3% (14·9% - 22·1%)	0·38 (0·23, 0·62)	<0·001
Amoy Gardens Block E residents	n=12 50·0% (21·1% - 78·9%)	n=24 33·3% (15·6% - 55·3%)	n=36 38·9% (23·1% - 56·5%)	0·50 (0·10, 2·54)	0·441[3]
Amoy Gardens other block residents	n=25 40·0% (21·1% - 61·3%)	n=82 13·4% (6·9% - 22·7%)	n=107 19·6% (12·6% - 28·4%)	0·23 (0·07, 0·72)	0·008[3]
All households of all IP	n=299 22·4% (17·8% - 27·6%)	n=581 11·0% (8·6% - 13·9%)	n=881 14·9% (12·6% -17·4%)	0·43 (0·29, 0·63)	<0·001
HMAR					
Hospital workers	n=349 3·4% (1·8% - 5·9%)	n =381 0·5% (0·06% - 1·9%)	n=730 1·9% (1·1% - 3·2%)	0·15 (0·02, 0·67)[2]	0·004
Other community members	n=392 15·8% (12·4% - 19·8%)	n=866 7·2% (5·5% - 9·1%)	n=1261 9·8% (8·3% - 11·6%)	0·41 (0·28, 0·61)	<0·001
Amoy Gardens residents (Block E)	n=27 37·0% (19·4% - 57·6%)	n=51 17·7% (8·4% - 30·9%)	n=78 24·4% (15·4% - 35·4%)	0·36 (0·11, 1·19)	0·058
Amoy Gardens residents (not Block E)	n=59 22·0% (12·3% - 34·7%)	n=196% 7·7% (4·4% - 12·3%)	n=255 11·0% (7·4% - 15·5%)	0·29 (0·12, 0·71)	0·002
All households of all IP	n=827 11·7% (9·6% - 14·1%)	n=1494 5·9% (4·8% - 7·2%)	n=2324 8·0% (6·9% - 9·1%)	0·47 (0·34, 0·64)	<0·001

1 the reference group is before March 25
2 exact 95% CI
3 Fisher's exact test p-value

Table 3. Univariate analysis of associations between risk factors and Household Attack Rates (HAR)

Risk factor	Any probable secondary case within the household: Yes	No	Odds ratio (95% CI)	*Chi-square* *P* value[1]
Gender of Index Person (IP)				
Male (n=400)	16·5%	83·5%	1·00	0·215
Female (n=481)	13·5%	86·5%	0·79 (0·55, 1·15)	
Age of IP[1]				
≤30 (n=283)	7·4%	92·6%	1·00	<0·001
31-40 (n=197)	11·2%	88·8%	1·57 (0·84, 2·93)	
41-50 (n=165)	19·4%	80·6%	3·00 (1·67, 5·41)	
51-60 (n=76)	23·7%	76·3%	3·87 (1·94, 7·73)	
61+ (n=138)	23·2%	76·8%	3·77 (2·08, 6·83)	
Type of IP				
Hospital workers (n=267)	3·7%	96·3%	1·00	<0·001
Amoy Gardens Block E residents (n=36)	38·9%	61·1%	16·35 (6·51, 41·08)	
Amoy Gardens other block residents (n=107)	19·6%	80·4%	6·28 (2·84, 13·85)	
Other community members (n=471)	18·3%	81·7%	5·74 (2·93, 11·26)	
Date of IP's fever onset[2]				
Before March 25 (n=299)	22·4%	77·6%	1·00	<0·001
On or after March 25 (n=581)	11·0%	89·0%	0·43 (0·29, 0·62)	
Duration IP stayed home between fever onset and hospitalization[3]				
≤2 days (n=440)	9·3%	90·7%	1·00	<0·001
3-5 days (n=268)	15·3%	84·7%	1·76(1·11, 2·79)	
≥6 days (n=171)	28·7%	71·3%	3·91(2·46, 6·20)	
IP visited by any household member during hospitalization?				
No (n=682)	12·6%	87·4%	1·00	0·001
Yes (n=199)	22·6%	77·4%	2·03 (1·36, 3·03)	
Disinfection of IP's quarters?				
Yes	15·2%	84·8%	1·00	0·884
No	14·7%	85·3%	0·96 (0·66, 1·40)	

1. Excluded 22 missing individuals
2. Excluded 1 missing individual
3. Excluded 2 missing individuals

Table 4. Summary of stepwise multivariate logistic regression model predicting "probable secondary infection" within the household level

Risk factor	Coefficient	SE	Odds ratio (95% CI)	*P* value
Type of Index Person (IP)				
Health care worker			1·00	
Amoy Gardens Block E residents	3·074	0·487	21·62 (8·33, 56·10)	<0·001
Amoy Gardens other block residents	1·901	0·425	6·69 (2·91, 15·39)	<0·001
Other community member	1·705	0·354	5·50 (2·75, 11·01)	<0·001
Date of IP's fever onset				
Before March 25			1·00	
On or after March 25	-0·696	0·235	0·50 (0·32, 0·79)	<0·001
Duration IP stayed home between fever onset and hospitalization				
≤2 days			1·00	
3-5 days	0·283	0·258	1·33 (0·80, 2·20)	0·274
≥6 days	1·045	0·265	2·84 (1·69, 4·78)	<0·001
IP visited by any household member when hospitalized?				
No			1·00	
Yes	0·483	0·242	1·62 (1·01, 2·60)	0·046

1 Age was not significant in the multivariable analysis

Table 5. Univariate association between various risk factors and HMAR

Risk factor	Case (n=131)	Control (n=2139)	Odds ratio (95% CI)	Chi-square *P* value
Gender[1]				
Male	46·6%	48·3%	1·00	0·701
Female	53·4%	51·7%	1·07 (0·75, 1·53)	
Age[2]				
18-30 years	46·6%	46·9%	1·00	0·287
31-40 years	15·3%	15·3%	1·17(0·68, 2·01)	
41-50 years	16·2%	16·3%	1·04(0·60, 1·81)	
51-60 years	10·9%	10·7%	1·58(0·90, 2·76)	
≥61 years	11·1%	10·8%	1·65(0·95, 2·86)	
Type of Index Person (IP)				
Hospital care workers	7·6%	33·5%	1·00	<0·001[3]
Amoy Gardens Block E residents	10·7%	2·8%	16·99(7·23, 39·90)	
Amoy Gardens other block residents	15·3%	10·6%	6·31(2·91, 13·67)	
Other community members	66·4%	53·2%	5·48(2·83, 10·61)	
Date of IP's fever onset[4]				
Before March 25	51·9%	34·2%	1·00	<0·001
On or after March 25	48·1%	65·8%	0·48 (0·34, 0·69)	
Duration IP stayed home between fever onset and hospitalization [5]				
≤2 days	31·3%	51·0%	1·00	<0·001
3-5 days	32·1%	30·3%	1·72(1·11, 2·68)	
≥6 days	36·6%	18·8%	3·18(2·07, 4·90)	
IP visited by a family member during hospitalization?				
No	73·3%	87·9%	1·00	<0·001
Yes	26·7%	12·1%	2·65 (1·76, 3·98)	
Mask use during hospital visits by a household member[6]				
Not visited by any household member	75·0%	88·6%	1·00	<0·001[3]
Visited, both with mask on	6·3%	4·0%	1·87(0·88, 3·96)	
Visited, one with mask on	5·5%	3·6%	1·78(0·80, 3·96)	
Visited, both without mask on	13·3%	3·8%	4·16(2·37, 7·30)	
Whether caretaker of IP				
No	64·9%	82·0%	1·00	<0·001
Yes	35·1%	18·0%	2·47 (1·70, 3·60)	
Whether shared room and bed with IP[7]				
Never	59·7%	81·3%	1·00	<0·001
Sharing room	8·9%	7·3%	1·66(0·86, 3·19)	
Sharing room and bed	31·5%	11·4%	3·74(2·48, 5·64)	
Frequency of dining together with IP[8]				
Never	37·0%	60·2%	1·00	<0·001

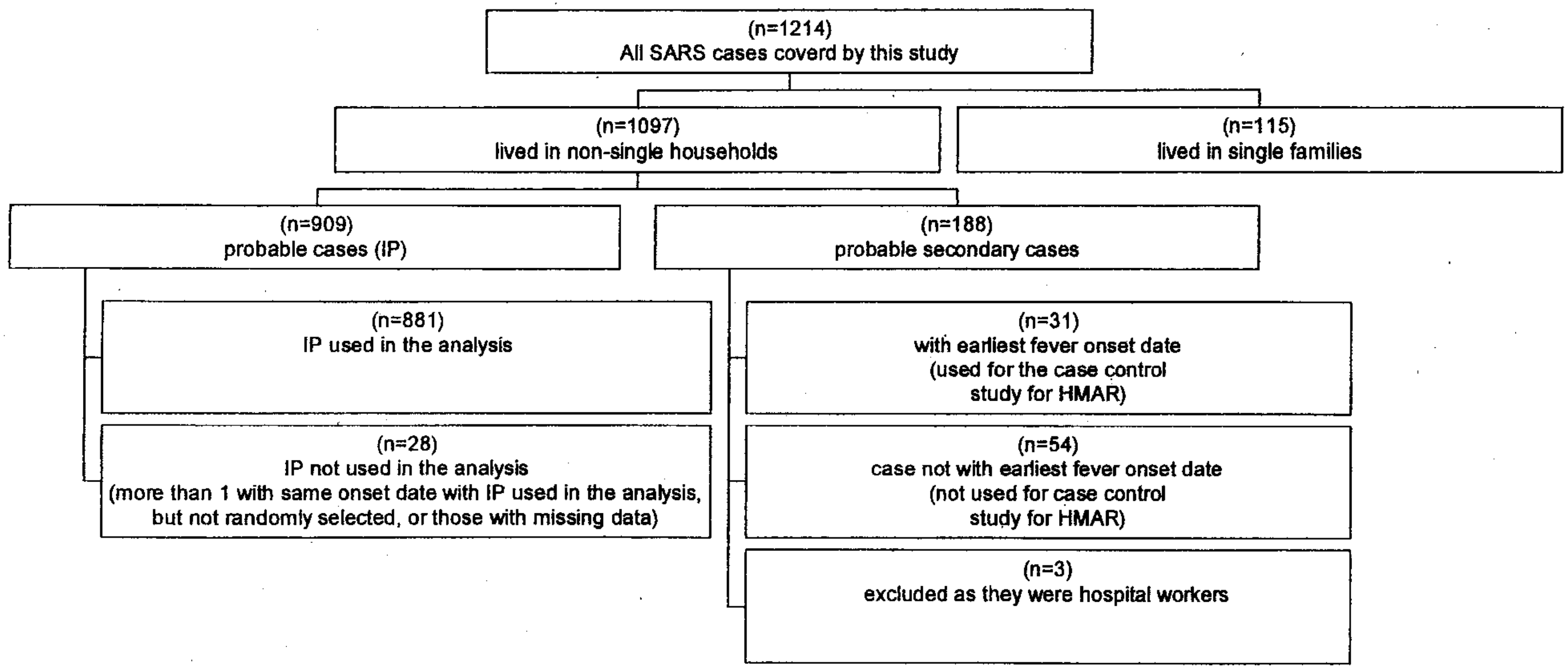
<5	21·8%	18·7%	1·90(1·15, 3·12)	
5-10	14·3%	9·7%	2·40(1·35, 4·29)	
>10	26·9%	11·4%	3·82(2·38, 6·15)	
Frequency of close contact with IP (within 1 meter)[9]				
Never	22·5%	48·4%	1·00	<0·001
Seldom	15·0%	14·7%	2·19(1·19, 4·02)	
Occasionally	24·2%	16·4%	3·17(1·85, 5·42)	
Frequent	38·3%	20·5%	4·03(2·47, 6·56)	
Frequency coughed at by IP (within 1 meter)[10]				
Never	77·6%	90·3%	1·00	<0·001[3]
Seldom	6·5%	4·2%	1·81(0·81, 4·03)	
Occasionally	10·3%	2·8%	4·29(2·17, 8·48)	
Frequent	5·6%	2·6%	2·47(1·03, 5·90)	

1. Information on 31 controls missing
2. Information on 7 cases and 160 controls missing
3. Chi-square test exact p-value
4. Information on 3 controls missing
5. Information on 6 controls missing
6. Information on 3 cases 18 controls missing
7. Information on 7 cases and 24 controls missing
8. Information on 12 cases and 51 controls missing
9. Information on 13 cases and 37 controls missing
10. Information on 24 cases and 98 controls missing

Table 6. Summary of multivariate logistic regression model predicting"probable secondary infection" at household members (N=2195)

Risk factor	Coefficient	S.E.	Odds ratio (95% CI)	*P* value
Type of Index Person (IP)				
Hospital care workers			1·00	
Amoy Gardens Block E residents	2·888	·455	17·95 (7·35, 43·83)	<0·001
Amoy Gardens other block residents	1·661	·419	5·26 (2·32, 11·95)	<0·001
Other community members	1·387	·352	4·01(2·01, 7·98)	<0·001
IP visited by a household member				
Not visited by any			1·00	
Both with mask	·571	·412	1·77 (0·79, 3·97)	·166
Either one with mask	·483	·429	1·62 (0·70, 3·76)	·260
Both without mask	1·139	·326	3·12 (1·65, 5·91)	<0·001
Frequency of close contact with IP (within 1 m)[9]				
Never			1·00	
Seldom	·466	·338	1·59 (0·82, 3·09)	·168
Occasionally	·762	·304	2·14 (1·18, 3·89)	·012
Frequently	·834	·288	2·30 (1·31, 4·05)	·004
Date of IP's fever onset				
Before March 25			1·00	
On or after March 25	-·681	·220	0·51 (0·33, 0·78)	·002
Duration Index person stayed home between fever onset and hospitalization				
≤2 days			1·00	
3-5 days	·092	·278	1·10 (0·64, 1·89)	·740
≥ 6 days	·655	·278	1·93 (1·12, 3·32)	·018

Figure 1 Distribution of the SARS patients covered in this study



Monitoring Community Responses to The SARS Epidemic in Hong Kong – from Day 10 to Day 62

Joseph T.F. LAU, [redacted]

Centre for Epidemiology and Biostatistics, School of Public Health, Faculty of Medicine,

The Chinese University of Hong Kong, Hong Kong, China

Correspondence and reprint addressed to:

Dr. Joseph T.F. LAU

Centre for Epidemiology and Biostatistics

5/F, School of Public Health, Prince of Wales Hospital

Shatin, N.T., Hong Kong

Tel: (852) 2637-6606

Fax: (852) 2645-3098

Email: jlau@cuhk.edu.hk

Word count for abstract and main body text:

Abstract: 246; Main body text: 2646

Running title: Responses of Hong Kong Community to SARS

Abstract

Study Objective-To document the evolution in perceptions and behaviours of the general public in response to the Severe Acute Respiratory Syndrome (SARS) epidemic in Hong Kong.

Design-Ten identical and sequential telephone surveys during outbreak of SARS, divided into the first and second phases of the epidemic.

Setting-Hong Kong, China

Participants-1397 Hong Kong residents of ages 18-60 years.

Main Outcome Measures- Perceptions and behaviours to SARS and its prevention.

Results- Most of the respondents believed that SARS could be transmitted via direct body contact and droplets. About half of respondents believed that SARS is curable, which increased in the initial phase and dropped in the second phase. Perceived chance of infection was low (9%) but fear of infection in public places was high (48%). Perceived efficacy of hygiene measures (wearing a mask: 82%, hand-washing 93% and home disinfection: 75%) remains high in both phases and the perceived efficacy of avoiding of crowded place, and using public transportation, etc., increased initially and decreased in the second phase. In parallel, use of the three hygiene measures increased significantly in the first phase and remained high for wearing a mask and washing hands in the second phase. Percentages of individuals avoiding crowded place and public transportation significantly increased initially and decreased in the second phase.

Conclusion Hong Kong residents quickly adopted relevant prevention measures related with SARS. Perceptions and behaviours changed quickly over time. To keep people well-informed is the key to cope with the public health crisis.

Key Words: SARS, Outbreak, Behaviours

BACKGROUND

The first outbreak of the Severe Acute Respiratory Syndrome (SARS) epidemic in Hong Kong occurred in the Prince of Wales Hospital (PWH) on March 10, 2003 (1). The second large-scale outbreak occurred in the community around March 26, in which total of 321 residents in the Amoy Garden were affected. On March 31, all Block E residents were quarantined at home and then moved to 2 quarantine camps on April 1. The number of newly reported cases (n=80) peaked in Hong Kong, and declined to less than 10 cases per day after May 3, 2003. On March 31, 2003; the World Health Organization (WHO) issued a travel warning to Hong Kong on April 2, 2003. Up to May 25, 2003, there were 1725 confirmed and suspected SARS cases reported in Hong Kong (2).

Knowledge, attitudes, behaviors and practice (KABP) studies are commonly examined to investigate patterns of community responses to the development and prevention of a disease (3-7). As a newly emerging disease, SARS is a new disease and interactively, public's attitudes, belief and behaviors would determine the effectiveness of the prevention of the disease. The study aims to document the evolution and changes in attitudes, knowledge and behaviours of Hong Kong residents in response to the public health crisis.

Subjects and Methods

Respondents

The study population includes all Chinese Hong Kong residents who were of age 18-60. Telephone surveys using a structured questionnaire and random telephone numbers selected from up-to-date telephone directories were conducted. Almost 100% of the Hong Kong residents have telephones at home (Hong Kong Office of the Telecommunications Authority, personal communication, January 28, 2000). Interviewers were carried out during 6:00 to 10:00 pm, to avoid over-representation of non-working people. Household members whose birthday was closest to the interview date were invited to join the study. For non-contacts, at least 3 calls were made on different dates of the week and at different hours.

Since the PWH outbreak, ten rounds of surveys were carried out on March 21 (Day 10 since the PWH outbreak), 22, 23, 24, and 28, April 1, 8, 11, and 24, as well as on May 12 (Day 10 to 62 since the PWH outbreak). Among contacted households with an eligible potential respondent answering the call (n=2424), 1397 agreeing and 1027 refusing to participate. The response rate was thus 57.6% (1397/2424).

Ethics approval has been obtained from the Ethics Committee of the Chinese University of Hong Kong and workable informed consent obtained from all respondents of the survey.

Measurements

Respondents were requested to provide information on different perceptions and behaviours related to SARS (See Table 2 to 5). While the majority of the questionnaire items were asked on all dates of the survey, a subgroup of items were asked only in the early part of the survey and another subgroup was only asked in the later dates of the survey in order to maintain the length of the interview to less than 15 minutes. The dates that specific questionnaire items were asked are listed in the relevant tables and text.

Statistical methods

The distributions of responses were tabulated and were tested using Chi-square test for trend in two phases (up to and after April 1, i.e., around the peak of the epidemic). Odds ratios were derived by using multiple logistic regression models. Forward stepwise selection of variables was used to identify factors predictive of different types of preventive behaviors. SPSS for Windows Release 11.0.1 (SPSS Inc., Chicago, USA) was used to analyze the data and p values less than 0.05 were considered as statistically significant.

RESULTS

Background characteristics

A total of 1397 Hong Kong residents participated in the surveys. Men were slightly more than women (51.4% vs. 49.4%). Respondents of 18-29, 30-39, 40-49 years of age accounted for 26.7%, 25.2% and 28.2%, respectively, and 20% of respondents were aged 50-60 years. The majority of respondents received an education between middle school grade four and pre-college. 27.1% of them had tertiary education and 28.3% had an educational level below middle school grade four. Variations in distribution of genders, age, education levels and nature of work of the respondents were not significant among surveys.

Perceived mode of transmission, cure and fatality

As summarised in Table 1, a majority of the respondents believed that this disease could be transmitted via direct body contact with SARS patients and via droplets (84.4%, 97%, $p>0.05$). Percentages of respondents believing that SARS could be transmitted via aerosol and articles touched by patients, increased in the first phase and leveled off in the second phase. Over half of the respondents believed that environmental contamination was a mode for the disease transmission. More and more respondents believed the disease to be curable in the initial phase ($p<0.001$) but the figure decreased in the second phase ($p<0.001$). The converse was observed for the percentages believing SARS to be fatal ($p<0.001$).

[Insert Table 1 here]

Perceived susceptibility of contacting SARS

The results are shown in Table 1. The trends of perceived susceptibility was not significant in the first phase and they declined in the second phase (self susceptibility: 4% on March 21st, 12% on April 1st, $p=0.124$ and decreased to 5% on May 12th, $p=0.038$; susceptibility of family members: 6.4% on March 21st, 11.4% on April 1st, $p=0.430$, and decreased to 1% on May 12th, $p=0.017$). Approximately, 34% of the respondents felt "Worried/very worried" about their own or their family members' contracting of the virus; the figure dropped sharply in the most recent survey (18% on 12/5, OR<0.5 and $p<0.05$). The percentage of respondents who feared that they would contract the virus in public places also declined in the second phase of epidemic (from 52% on 1/4 to 36% on 12/5, $p=0.001$).

Perceived risk of transmission at different places

Table 3 summarises the perceived risk of transmission in various public places. In general, the percentages of respondents perceiving a high chance of transmission in different places increased in the initial phase and decreased in the second phase (See Table 2). In the initial phase, more and more respondents believed that traveling to Guangdong, China was associated with a "High/very high" risk of transmission (71% on March 21^{st} to 83% on April 1^{st}, $p=0.010$), it was not significant in the second phase ($p=0.404$). The trend for perceived "High/very high" risk for visiting other provinces of China increased significantly all along the study period (37% on March 21st, 64% on April 1st, and 72% on May 12th, See Table 2).

[Insert Table 2 here]

Perceived efficacy of various means of prevention

The results are shown in Table 3. In the initial phase, there were significant increases in the percentage of respondents perceiving "Wearing a mask" ($p=0.034$); "Frequent hand washing" ($p<0.001$) and "Home disinfection" ($p=0.006$) as effective means of prevention. These trends were, however, not significantly in the second phase.

In the initial phase, significantly increasing percentages of respondents also believed "Avoid going to different public places" (e.g. public transportation and cinema, etc.) to be useful means of prevention of SARS; In the second phase, these figures all significantly decreased to a lower level. The percentages of respondents who perceived "Avoid visiting hospitals/clinics" (88%), "Avoid visiting China" (83%) and "Leaving Hong Kong for a while" (20%) as "Very useful/useful" means of prevention were fairly stable over time ($p>0.05$).

[Insert Table 3 here]

Practice of preventive measures/behaviours

In the initial phase, the reported frequencies of all preventive behaviors rose dramatically; in the second phase, decreasing trends were observed for these items (See Table 4). However, percentages that indicated an intention to "Avoid visiting to China" (71%) and "Leave Hong Kong temporarily" (4%) were stable over the study period (See Table 4).

[Insert Table 4 here]

Attitudes related to wearing a mask

Only a small percentage of the respondents would avoid someone wearing a mask (5% on March 28th and 7% on May 12th, $p=0.858$). The majority of them (95%) regarded it as a civic responsibility and indicated that they would wear a mask in public places as frequently as possible and that they would wear a mask in public places, had they had any flu-like symptoms (Data not tabulated).

Perceived severity of the disease

Fewer respondents of the later surveys believed that the epidemic would last for less than three months (from 81% on April 1st to 65% on May 12th, $p<0.001$). The percentage of respondents believing a high chance of occurrence of a large-scale outbreak in Hong Kong increased in the initial phase ($p<0.001$) and then became steady until 12 May (12%, $p<0.001$). Fewer respondents believed that the epidemic had largely been under control (27% on March 21st and 12% on April 1st, $p<0.001$) until 12 May·03 (73%, $p<0.001$). The majority of the respondents supported the "Quarantine policy" (85.8%) and believed that it was effective (over 90%, $p>0.05$). A remarkably high proportion indicated that they would comply with that policy, had they had close contacts with SARS patients (91%, $p=0.183$ from April 1st to May 12th) (Data not tabulated).

Factors associated with protective behaviors

Controlling for the date of interviews, female respondents (OR:2.017, 95% CI: 1.293-3.314), those who believed that the virus could be transmitted via aerosols (OR:1.907, 95% CI: 1.211-3.004), those working in hospitals (OR: 3.440, 95% CI: 1.653-7.158), and those who perceived wearing a mask as an efficacious means of prevention (OR: 7.151, 95% CI: 4.245-12.045) were more likely than others to wear a mask, while people who believed that SARS was under control in Hong Kong were less likely than others to report wearing a mask (OR: 0.378, 95% CI: 0.218-0.656).

Similarly, controlling for the date of interviews, those who were female (OR:1.841, 95% CI: 1.062-3.194), older (OR: 2.294 for the 30-39 group, 2.267 for 40-49 and 2.477 for 50-60 the group), who were "Very worried/worried" about themselves and their family members being infected with SARS (OR:2.270, 95% CI: 1.212-4.253) and perceived frequent hand-washings to be efficacious in preventing SARS (OR: 31.996, 95% CI: 13.876-73.781) were more likely than others to report frequent hand-washing.

DISCUSSION

The vast global consequence of SARS is not limited to the impact on those who were infected with the virus, but extends to everyone in the affected communities. Hong Kong, being among the first cities to deal with a major SARS outbreak when etiologic agent was unknown, has experienced an inordinate amount of public distress. For instance, there was an inversion of percentages perceiving SARS would be curable and not fatal. Despite this, people in Hong Kong had been realistic in assessing their susceptibility to infection – less than 10% for most of the surveys and the trend was not significant even in the rising phase of the epidemic. Around 35% of the respondents worried about contracting the disease, but similarly, the figures were stable over time. Few reported the intention of avoiding work or leaving Hong Kong temporarily. In other words, no panic had grown in Hong Kong. The data thereby suggests that there was no widespread public panic even while the number of incident cases was increasing.

The prevalence of using a mask, adopting better hand hygiene and disinfection of living quarters increased dramatically within a week (from March 24 to April 1st, OR>4, $p<0.01$). This was also seen in the intention of other health measures prompted by the

Department of Health, such as "Avoid going to crowded places". These occurred in parallel with the increase in the number of reported cases. Transparency and timely dissemination of such data may therefore be very important in promoting preventive behaviors. It is important to note that despite respondents' perceived lower risk of infection at different public places during the declining phase of the epidemic, the prevalence of infection control measures practiced (mask, disinfections, hand washing) remained at high levels (e.g., 84% still wearing a mask on May 12, 2003).

Perceived efficacy of the preventive measure, perceived seriousness of the problem in the community, perceived susceptibility etc., in general, were predictors of preventive measures (such as mask wearing and hand hygiene). The findings are in line with factors described by the Health Belief Model (8). Females and older people were more likely to practice such measures than men and younger ones. Education about efficacy of different means, together with the above-mentioned data transparency, would therefore be expected to produce along behavioral changes in a timely and effective manner.

Quarantine of household contacts of SARS was implemented on April 10, 2003 (9). The policies have been highly supported by the public. It seems that the quarantine measure, together with a very high and consistent level of protective measures taken, accounted for the control of the epidemic in Hong Kong. This experience may prove useful to other affected countries in the future.

The trends of risk perception of transmission in different places (e.g. crowded places, in a lift, in restaurants, cinemas, public transportation etc.) also followed the number of reported cases per day closely - rising in the initial phase and declining in the later phase of the epidemic. The perception of risk was also related to behaviors such as avoidance of going outside or avoidance of going to public places. Our data shows that people in Hong Kong start returning to their normal routine, with fewer people considered going to public venues as being at high risk and fewer avoiding going out. Yet, there were still about 45% of the citizens avoiding going out. It is seen that more Hong Kong people were expecting that the epidemic would last longer than 3 months in Hong Kong, even in the second phase of the epidemic. The SARS epidemic severely affected the every aspect of life and may have created long-term health consequences.

Around 80% perceived a high risk of visiting Quangdong and increasing numbers perceived a high risk of visiting other provinces in mainland China (from 37% on March 21 to 72% on May 21), while about 70% stated that they would avoïd going to mainland China altogether. There are over fifty millions of cross-border activities in 2002 (10), the isolation of the two epidemics is hence virtually impossible. Surveillance, research and education to result in effective prevention measures are of utmost importance.

The study is limited in several ways. Firstly, data are self-reported and there may be some reporting bias. However, since trends were compared using the same questionnaire, internal validity has been maintained. Secondly, the sample size for each round of survey is not large, though the total sample size was about 1400. Thirdly, details related to preventive measures, such as frequency and context of mask wearing was not asked, as constrained by the length of the questionnaire. It however, has the strength of using identical repeated cross-sectional studies and covers the epidemic since its initial phase.

The epidemic of SARS in Hong Kong has been in decline since May 2003. Vital to the success was the introduction of adequate SARS prevention policies by Hong Kong Health Authorities during the epidemic, i.e. reducing population contacts, improved hospital infection control and more rapid hospital attendance(11). The effectiveness of these preventive measures are largely determined by the perceptions and, more importantly, subsequent behavioral chances of the public. Transmission dynamic models of SARS agent shows that increasing population contacts would increase the difficulty in eventually eradicating SARS in Hong Kong(11). There is still a need to continue the current preventive measures and to avoid high population-contacting activities.

Though the quarantine policy had been well supported, the public was not satisfied with the governmental responses and were doubtful about its ability to control the epidemic. A set of proactive control policies may need to be developed by governments of different countries. It is seen that the pattern of the epidemic curve would be a major determinant of important aspects including perception of risk and using preventive measures. For the SARS epidemic to be controlled in a country, both government and community behaviors need to be taken into account.

REFERENCES

1. Lee N, Hui D, Wu A, Chan P, Cameron P, Joynt GM, et al. A major outbreak of severe acute respiratory syndrome in Hong Kong. N Engl J Med 2003;348(20):1986-94.

2. Hong Kong Department of Health. Battling SARS Update / Press Release. Available from http://www.ha.org.hk/sars/ps/pressrelease/index.html:Accessed on May 25, 2003.

3. Carter J, Park ER, Moadel A, Cleary SD, Morgan C. Cancer knowledge, attitudes, beliefs, and practices (KABP) of disadvantaged women in the South Bronx. J Cancer Educ 2002;17(3):142-9.

4. Basuki E, Wolffers I, Deville W, Erlaini N, Luhpuri D, Hargono R, et al. Reasons for not using condoms among female sex workers in Indonesia. AIDS Educ Prev 2002;14(2):102-16.

5. Rahman M, Shimu TA, Fukui T, Shimbo T, Yamamoto W. Knowledge, attitudes, beliefs and practices about HIV/AIDS among the overseas job seekers in Bangladesh. Public Health 1999;113(1):35-8.

6. Chan R, Khoo L, Goh CL, Lam MS. A knowledge, attitudes, beliefs and practices (KABP) survey on HIV infection and AIDS among doctors and dental surgeons in Singapore. Ann Acad Med Singapore 1997;26(5):581-7.

7. Maticka-Tyndale E, Kiewying M, Haswell-Elkins M, Kuyyakanond T, Anursornteerakul S, Chantapreeda N, et al. Knowledge, attitudes and beliefs about HIV/AIDS among women in northeastern Thailand. AIDS Educ Prev 1994;6(3):205-18.

8. Fisher JD, Fisher WA. Theoretical Approaches to Individual-Level Change in HIV Risk Behavior. New York, Boston, Dordrecht, London, Moscow: KluwerAcademic/Plenum publishers; 2000.

9. Hong Kong Department of Health. Press Release: household contacts of AP patients ordered to stay at home. Available from: http://www.info.gov.hk/dh/ap.htm:Accessed on May 27, 2003.

10. Hong Kong Government Information Centre. Hong Kong Residents Departures by Destination. Available from: http://www.info.gov.hk/censtatd/eng/hkstat/hkinf/transport/transp8_index.htm:Accessed on May 27, 2003.

11. Riley S, Fraser C, Donnelly CA, Ghani AC, Abu-Raddad LJ, Hedley AJ, et al. Transmission Dynamics of the Etiological Agent of SARS in Hong Kong: Impact of Public Health Interventions. Published online 23 May 2003; 10.1126/science. 1086478. 2003.

Table 1 Knowledge and attitudes related to modes of transmission, cure, fatality and susceptibility

	Date of Interveiw												
	Initial Phase						Second Phase						
	21.3	22.3	23.3	24.3	28.3	1.4	8.4	11.4	24.4	12.5	All	P values †	P values ‡
Mode of Transmission													
Direct body contact with patients (% very likely/likely)	80.5	81.8	81.8	67.7	87.0	84.3	87.3	90.3 [b]	86.7	83.7	84.8	0.350	0.856
Droplets (%very likely/likely)	92.1	97.4	95.6	98.5	97.6	97.8 [b]	96.8	98.1 [c]	94.5	97.7 [b]	96.8	0.216	0.683
Aerosols (%very likely/likely)	39.0	40.7	40.0	58.5 [b]	46.7	48.4	37.2	34.4	30.3	30.2	39.5	0.181	<0.001
Articles touched by patients (%very likely/likely)	45.5	39.3	46.7	47.7	71.0 [b]	71.4 [b]	63.5 [b]	70.8 [b]	69.7 [b]	58.1 [a]	60.9	<0.001	0.316
Environment contamination (%very likely/likely)	-	-	-	-	-	-	56.1	55.2	60.6	55.2	56.8	-	0.917
SARS is curable ? (%Yes)	48.6	38.7	34.4	30.8 [r]	54.0	66.3 [b]	57.0	61.8	25.8 [r]	37.3	47.1	<0.001	<0.001
SARS is fatal ? (%Yes)	76.3	74.8	72.2	66.7	55.0 [r]	35.0 [q]	31.6 [q]	31.6 [q]	59.8 [r]	45.6 [r]	51.6	<0.001	<0.001
Susceptibility to SARS													
Perceived chance of infection for oneself (%very large/large)	3.9	9.2	8.8	11.1	14.3 [c]	12.4 [b]	7.0	7.1	7.3	4.7	8.7	0.124	0.038
Perceived chance of infection for family members (%very large/large)	6.4	11.8	7.7	7.9	11.9	11.4	9.5	10.4	9.7	1.2 [q]	9.0	0.430	0.017
Worried about oneself and family members being infected (% much worried/worried)	37.2	41.7	19.8 [r]	42.4	43.8	33.5	28.5	34.2	38.8	18.0 [r]	33.6	0.524	0.291
Fear of contracting the virus in public places (% much scared/scared)	-	-	-	-	55.6	52.4	53.2	50.3	43.6 [p]	35.5 [r]	48.4	0.548	0.001

† For comparison from 21/3 to 1/4 and derived from two-sided linear by linear Chi-square test; ‡ For comparison from 1/4 to 12/5 and derived from two-sided linear by linear Chi-square test; a, b and c : OR ≥1 and<2, ≥2 and<4, ≥4, respectively and p<0.05, for comparison with the reference (21 Mar 03) or the first column of data while controlling for age, gender and levels of education; p, r and q: OR ≥0.5 and<1, ≥0.25 and<0.5, <0.25, respectively, and p<0.05, for comparison with the reference (21 Mar 03) or the first column while controlling for age, gender and levels of education; - data not collected for those rounds of survey.

Table 2 Perceived risk of transmission at different places

	Date of Interveiw												
	Initial Phase					Second Phase							
	21.3	22.3	23.3	24.3	28.3	1.4	8.4	11.4	24.4	12.5	All	P values†	P values‡
Working in office	21.8	23.8	27.5	29.7	32.0	33.7	17.7	23.2	24.2	11.6	24.3	0.031	0.004
Using public transportation vehicles	40.0	52.0	50.5	57.8^{b}	66.9^{b}	62.7^{b}	38.0	54.8^{a}	48.5	38.4	51.4	0.004	0.077
Eating in restaurants	33.8	41.8	44.0	48.4	53.3^{b}	45.7	26.6	29.7	32.7	25.0	37.5	0.335	0.009
Walking in the street	11.7	15.0	18.7	24.6^{b}	19.5	15.1	5.7	7.1	7.9	6.4	12.2	0.744	0.055
Using lifts	-	-	-	-	-	55.1	37.3^{r}	44.5	32.1^{r}	30.8^{r}	40.2	-	<0.001
Going to cinema	31.2	41.4	44.0	47.7^{b}	56.8^{b}	57.6^{b}	35.0	39.4	47.3^{b}	25.0	43.0	<0.001	<0.001
Travelling to other regions													
Trips to Guangdong	71.1	77.1	69.7	72.7	82.1^{b}	83.2^{b}	75.9	83.2^{b}	89.7^{b}	77.3	79.6	0.010	0.404
Trips to other provinces, Mainland China	37.3	45.6	47.8	43.1	63.5^{b}	64.1^{b}	50.6^{a}	59.4^{b}	78.2^{c}	71.9^{c}	59.1	<0.001	<0.001

† For comparison from 21/3 to 1/4 and derived from two-sided linear by linear Chi-square test; ‡ For comparison from 1/4 to 12/5 and derived from two-sided linear by linear Chi-square test; a, b and c : OR ≥1 and<2, ≥2 and<4, ≥4, respectively and p<0.05, for comparison with the reference (21 Mar 03) or the first column of data while controlling for age, gender and levels of education; p, r and q: OR ≥0.5 and<1, ≥0.25 and<0.5, <0.25, respectively, and p<0.05, for comparison with the reference (21 Mar 03) or the first column of data while controlling for age, gender and levels of education; - data not collected for those rounds of survey.

Table 3 Perceived efficacy of means of prevention

	Date of Interveiw												
	Initial Phase						Second Phase						
	21.3	22.3	23.3	24.3	28.3	1.4	8.4	11.4	24.4	12.5	All	P values†	P values‡
Hygienic means													
Wearing a mask (% very effective/effective)	79.5	78.8	72.2	75.8	84.0	84.9	86.1	85.8	80.0	80.8	81.7	0.034	0.171
Washing hands frequently (% very effective/effective)	80.5	83.9	86.8	87.9	96.4[c]	98.9[c]	96.8[c]	94.2[c]	96.4[c]	96.5[c]	93.3	<0.001	0.109
Disinfecting home (% very effective/effective)	-	-	-	69.7	83.4[b]	88.1[b]	86.1[b]	88.4[b]	88.4[b]	80.1[a]	74.7	0.006	0.267
Avoid going to different places													
Aviod going outside (% very useful/useful)	62.8	55.8	61.5	51.5	72.8	75.1[a]	69.6	70.3	61.2	48.3	63.9	<0.001	<0.001
Aviod crowded places (% very useful/useful)	83.4	91.7	90.1	84.8	91.7[b]	95.1[c]	91.8[b]	95.5[c]	90.2	81.3	90.2	0.010	0.002
Aviod visiting hospitals/clinics (% very useful/useful)	85.7	83.3	86.8	74.2	94.6[b]	89.2	86.1	96.1[c]	90.9	82.6	87.9	0.068	0.861
Avoid using public transportation (% very useful/useful)	41.0	40.4	57.1[a]	37.9	65.7[b]	63.2[b]	52.5	52.3	51.2	32.7	50.5	<0.001	<0.001
Avoid going to work (% very useful/useful)	19.2	19.9	30.0	16.7	40.8[b]	49.7[c]	31.0	30.3	28.8	16.4	29.9	<0.001	<0.001
Not allow kids to go to school (% very useful/useful)	-	-	-	33.8	68.0[c]	64.9[b]	58.9[b]	62.1[b]	58.3[b]	39.0	57.0	0.028	0.001
Aviod going to mainland China(% very useful/useful)	-	-	-	-	82.2	84.3	80.4	85.7	89.6	76.7	83.1	0.610	0.986
Leave Hong Kong temporily (% very useful/useful)	19.5	16.0	16.7	18.2	25.0	21.6	21.5	21.9	17.8	15.7	19.6	0.240	0.183

† For comparison from 21/3 to 1/4 and derived from two-sided linear by linear Chi-square test; ‡ For comparison from 1/4 to 12/5 and derived from two-sided linear by linear Chi-square test; a, b and c: OR ≥1 and<2, ≥2 and<4, ≥4, respectively and p<0.05, for comparison with the reference (21 Mar 03) or the first column of data while controlling for age, gender and levels of education; p, r and q: OR ≥0.5 and<1, ≥0.25 and<0.5, <0.25, respectively, and p<0.05, for comparison with the reference (21 Mar 03) or the first column while controlling for age, gender and levels of education; - data not collected for those rounds of survey.

Table 4 Practice of prevention means

	Date of Interveiw												
	Initial Phase					Second Phase							
	21.3	22.3	23.3	24.3	28.3	1.4	8.4	11.4	24.4	12.5	All	P values†	P values‡
Hygiene Means													
Wearing a mask (%)	11.5	16.7	7.7	16.7	66.9 [c]	84.3 [c]	87.3 [c]	87.7 [c]	93.9 [c]	85.4 [c]	64.3	<0.001	0.225
Hands hydiene (%)	61.5	66.7	63.7	80.3 [b]	94.1 [c]	95.1 [c]	93.7 [c]	94.2 [c]	94.5 [c]	95.9 [c]	86.9	<0.001	0.676
Disinfecting homes (%)	-	-	-	36.4	56.8 [b]	69.4 [c]	72.2 [c]	80.0 [c]	83.5 [c]	73.1 [c]	70.1	<0.001	0.022
Bahaviours													
Aviod going outside(%)	28.2	28.2	31.9	36.4	50.0 [b]	57.1 [b]	62.4 [c]	58.7 [b]	47.3 [b]	36.3	45.8	<0.001	<0.001
Aviod the crowded places(%)	59.0	67.7	54.9	68.2	76.3 [b]	85.4 [c]	81.0 [b]	89.0 [c]	81.2 [b]	69.6 [a]	75.5	<0.001	0.036
Aviod visiting hospitals(%)	59.7	63.5	52.7	62.1	73.4 [a]	75.0 [b]	76.4 [b]	86.5 [c]	79.9 [b]	68.6	71.8	0.001	0.892
Aviod public transportation(%)	14.1	15.4	16.5	24.2	26.6 [b]	36.2 [b]	27.8 [b]	31.0 [b]	25.0 [b]	17.1	24.4	<0.001	0.002
Avoid going to work (%)	-	2.6	2.2	4.5	6.1	8.1	7.7	7.3	5.5	1.2	4.9	0.002	0.018
Not allow kids to go to school (%)	-	-	-	12.5	35.7 [c]	38.1 [c]	31.0 [b]	36.7 [c]	39.6 [c]	16.3	31.6	0.013	0.032
Aviod going to China (%)	-	-	-	-	64.5	69.6	72.2	75.5 [a]	78.7 [b]	65.1	70.8	0.312	0.835
Leave Hong Kong temporily while (%)	5.1	2.6	3.3	6.2	2.4	5.4	2.5	3.2	6.1	2.9	3.8	0.340	0.876

† For comparison from 21/3 to 1/4 and derived from two-sided linear by linear Chi-square test; ‡ For comparison from 1/4 to 12/5 and derived from two-sided linear by linear Chi-square test; a, b and c : OR ≥1 and<2, ≥2 and<4, ≥4, respectively and p<0.05, for comparison with the reference (21 Mar 03) or the first column of data while controlling for age, gender and levels of education; p, r and q: OR ≥0.5 and<1, ≥0.25 and<0.5, <0.25, respectively, and p<0.05, for comparison with the reference (21 Mar 03) or the first column while controlling for age, gender and levels of education; - Data not collected for those rounds of survey.

WHY HOSPITAL WORKERS CAME DOWN WITH SARS—A MATCHED CASE-CONTROL STUDY OF BREAKTHROUGH TRANSMISSION AMONG HOSPITAL WORKERS IN HONG KONG

Joseph T.F. Lau, Ph.D.[1]
[redacted] FRCPA [2]
[redacted] MD [3]
[redacted] Sc.D. [1]
[redacted] M.A. [1]
[redacted] MD [4]
[redacted] BSc [2]
[redacted] MD [5]
[redacted] BB ChB [6]
[redacted] FRCPath [2]

[1]Centre for Epidemiology and Biostatistics,
School of Public Health, Faculty of Medicine
The Chinese University of Hong Kong
[2] Department of Microbiology, The Chinese University of Hong Kong
[3]Department of Community and Family Medicine, The Chinese University of Hong Kong
[4] Department of Surgery, Chinese University of Hong Kong
[5] Department of Obstetrics and Gynecology, The Chinese University of Hong Kong
[6] Hospital Authority, Government of Hong Kong

Total page count: 19 (including cover page, citations and tables)
Abstract word count: 249
Total word count: 2663 (excluding abstract and references and tables)
Keywords: SARS, hospital workers, nosocomial infections, breakthrough transmission, Hong Kong

Address for correspondence and reprint requests:

Dr. Joseph T. F. Lau, Director
Centre for Clinical Trials and Epidemiological Research
Faculty of Medicine, The Chinese University of Hong Kong
5/F, School of Public Health, Prince of Wales Hospital,
Shatin, NT; Hong Kong SAR
Tel (852) 2637-6606
Fax (852) 2645-3098
Email:jlau@cuhk.edu.hk

ABSTRACT

Background
Despite the institution of stringent infection control measures, many hospital workers in Hong Kong had been infected with severe acute respiratory syndrome (SARS).

Methods
Seventy-two hospital workers working with SARS patients and who contracted SARS were compared with matched controls with regard to a number of potential risk factors

Results
Inconsistent use of goggles, gowns, gloves and caps (univariate OR=2.42 to 20.54, $p< 0.05$) were associated with higher risk of SAR infection among hospital workers. There was a strong association between the number of personal protection equipment (PPE) perceived to be inadequate in supply and the likelihood of SARS infection. Hospital workers having >=2 hours of training had a much lower risk of infection (univariate OR=0.03, $p<0.0001$) and those who did not understand infection control procedures were at a higher risk (univariate OR=3.14, $p=0.0065$). There were no significant differences between the case and control groups in the proportion of workers who performed high-risk procedures, reported minor PPE problems or had social contact with SARS-infected individuals. Inconsistent hand hygiene when there was "no patient contact." was associated with SARS infection (univariate OR=6.38, $p=0.0044$). In the multivariate analysis, perceived inadequacy of PPE supply, infection control training < 2 hours and inconsistent use of PPE when in contact with SARS patients were significant risk factors for SARS infection.

Conclusions: Breakthrough transmission occurred among hospital workers in Hong Kong. Consistent use of PPE, adequate training and adequate PPE supply are required to reduce the risk of breakthrough SARS infection among hospital workers.

INTRODUCTION

The first large-scale outbreak of Severe Acute Respiratory Syndrome (SARS) occurred around March 12, 2003 in the Prince of Wales Hospital (PWH) in Hong Kong.[1] In this worldwide epidemic, hospital workers form one of the most adversely affected groups. Despite heightened global awareness, cases of affected hospital workers have been reported in different cities including Singapore, Toronto, Beijing, Taiwan as well as Hong Kong. As of May 31st, 2003, 384 out of 1739 (22.1%) suspected or confirmed cases reported in Hong Kong were hospital workers.[2]

In the initial phase of the epidemic hospital workers did not take special protective measures. Thus, hospital workers accounted for 43.6% (68 of the 156 cases) of those admitted to the PWH between March 11 and 25th, 2003.[3] Since then cases of hospital workers' infection had been reported in other hospitals in Hong Kong. By May 25th, 2003, 453 confirmed SARS cases have been admitted to hospitals in the New Territories East (NTE) Cluster of the Hospital Authority in Hong Kong, which serves 1.3 million people and to which the Prince of Wales Hospital belongs. Between March 28, 2003 and May 29th, 2003, a total of 77 cases of SARS infection among hospital workers had been reported by the 5 hospitals in the Cluster.

A recent study examined 13 hospital worker SARS cases and 241 controls charged with taking care of 11 SARS patients in 5 Hong Kong hospitals.[4] The authors concluded that the use of protective mask is an effective countermeasure against SARS, yet around 300 more hospital workers have contracted the disease despite implementation of these measures. The scenario presented in that article was atypical of the hospital workers' infection cases in Hong Kong, as many of them have always been using a mask and were caring for as many as several hundred SARS patients. Limitations of that study included the small number of cases and potential confounding by the possible differences in the intensity of care given to the SARS patients between the case and control groups.

The question why breakthrough transmission continues to occur despite the implementation of strict infection control measures has been puzzling hospital workers and researchers all over the world. The study aims to investigate the factors associated with breakthrough transmission of the SARS virus among hospital workers that were affected in hospital settings.

METHODS

STUDY DESIGN

A 1:2 matched case control design was used. All subjects were serving in wards with SARS inpatients, in some of these wards both SARS and non-SARS patients were hospitalized. The case group was to include all affected hospital workers in the five hospitals of the NTE Cluster of the Hospital Authority in Hong Kong, who were confirmed SARS cases and were hospitalized between March 28 and May 25, 2003. The SARS case definition criteria are radiographic evidence of infiltrates consistent with pneumonia, and current fever higher than 38°C or a history of such at any time in the preceding 2 days, and at least two of the following: history of chills in the past 2 days, cough, or breathing difficulty, general malaise or myalgia, and known exposure.

There were a total of 77 confirmed cases, out of which 72 (93.5%) joined the study. As all staff was required to use protective masks from March 12, 2003, these hospital workers presumed to have contracted the virus as a result of breakthrough transmission. An infection control nurse explained the purpose and logistics of the study to the study participants, obtained their verbal consent for participation, presented them with a structured questionnaire and collected the completed questionnaire. SARS cases were asked to nominate two colleagues of the same job position who had been working in the same ward and in proximity with the case before he/she felt unwell to serve as controls. Medical and nursing staff

(48 out of 72 cases) self-administered the questionnaires while other staff cases (e.g. health care assistants and ward assistants, etc) were interviewed by the infection control nurse. Control questionnaires of 57 cases were collected by the "nomination method." Nominated controls who did not return the questionnaire were replaced by controls that were randomly selected from the duty roster of the day before the case felt unwell, matching for job position. Of the 144 controls completing the questionnaire, one was invalidated because she later became a suspected case.

MEASUREMENTS

Questions were asked about the hospital worker's job position, whether he/she had been seconded from another unit, whether he/she had made physical contact with any SARS patients and if so, whether high-risk procedures were performed to the SARS patient (including intubation, suction, cardiopulmonary resuscitation).

Personal protection equipment (PPE) use (N95 mask, surgical mask, gloves, goggles, gown and cap) was examined under three different settings: when having direct contact with SARS patients, when having contact with "patients in general" (includes both SARS and non-SARS patients) and when there was "no patient contact." Information about the frequency of using different types of PPE (never, occasionally, most of the time, or all of the time) was asked for each of these three settings. A respondent was considered to be exposed to a particular risk if he/she had "never" or "occasionally" been using PPE rather than "most or all of the time". Those who had not been in contact with any SARS patients or "patients in general" were considered as not having been exposed to the particular risk. Respondents were asked whether they perceived the supply of such PPE items to be adequate or not (yes/no). Questions regarding the frequency of hand washing after making contact with SARS patients, "patients in general" and when there was "no patient contact" (never, occasionally, most of the time, all of the time) were also asked. In the analysis, frequency of using PPE and frequency of hand hygiene practice were coded into 2 categories: used inconsistently (i.e. "never or occasionally used") or used consistently (" used most or all of the time").

Study subjects were also asked to assess whether the masks fit them (yes/no), whether their goggles were fogged (yes/no) and the frequency of touching protective masks (never, occasionally, most of the time, or always), and whether they had any problems complying with infection control procedures (yes/no). The respondents were asked whether they had made social contacts with others who were later found to be SARS cases (yes/no/not sure).The questionnaire also asked about the respondent's exposure to infection control training (length of SARS infection control training) and whether they understood the infection control measures (yes/no). A trained research assistant contacted the respondents by telephone to follow up on any incomplete or unclear answers.

STATISTICAL METHODS

Univariate matched odds ratios calculated from conditional logistic regression methods were obtained [5]. A forward stepwise conditional logistic regression analysis was conducted using all variables that were marginally significant ($p<0.10$) in the univariate analyses as candidates for selection. Matched odds ratios and their exact 95% confidence intervals were derived. LogXact for Windows version 4.1 was used for all calculations.[6]

RESULTS

BACKGROUND CHARACTERISTICS OF RESPONDENTS

The 72 SARS-infected health care workers worked in 5 hospitals (distribution: 50% Alice Ho Miu Ling Nethersole Hospital, 40.3% from PWH, 2.8% from North District Hospital, 4.2% from Shatin Hospital, and 2.8% from Taipo Hospital). The study sample was comprised of nurses 59.7% (n=43), health care assistants 23.6% (n=17), medical officers 9.7% (n=8), clerical staff (2.8%, n=2) and workmen (4.2%, n=3).

USE OF PROTECTIVE MASKS

Almost 100% of the study respondents had been using either an N95 mask or surgical mask in all 3 settings (see Table 1). The SARS infections that occurred thus reflect breakthrough transmissions. The differences of the use of the N95 mask (most of those not wearing a N95 mask were wearing a surgical mask) were not statistically significant between cases and controls in any of the three settings ($p>0.05$, Table 1).

USE OF OTHER TYPES OF PPE

When hospital workers were in direct contact with SARS patients, the case group was more likely to be inconsistent users of goggles (OR=6.41, $p<0.0001$), gowns (OR=8.85, p=0.0002), gloves (OR=20.54, p=0.0002) and caps (OR=7.30, p=0.0001) than the control group. When in direct contact with "patients in general," cases were more likely to be inconsistent users of goggle (OR=6.93, p=0.0003), gowns (OR=11.54, p=0.0002) and caps (OR=12.81, p=0.0001). When there was "no patient contact," cases had more than a two-fold likelihood of inconsistent use of the goggles (p=0.0046), gown (p=0.0061), gloves (p=0.0374) or cap (p=0.0009), as compared to their matched controls. The number of PPE inconsistently used (including masks) in the three settings was also a significant predictor of SARS infection (OR=3.4-10.83, $p<0.05$, see Table1).

PERCENTAGES OF HOSPITAL WORKERS WITH INCONSISTENT HAND HYGIENE

Over 97% of both the cases and control group consistently practiced good hand hygiene after contacting SARS patients or "patients in general" (p=0.22, and p=1.00, respectively, Table 2). There was, however, a statistically significant difference in the proportion of cases (14.3%) and controls (2.1%) of hospital workers who reported inconsistent hand hygiene when there was "no patients contact" (OR=6.38, 95% CI=1.64, 36.2, p=0.0044).

PERCEIVED INADEQUACY OF PERSONAL PROTECTION EQUIPMENT SUPPLY

A much higher percentage of SARS cases reported a perceived inadequate supply of each of the 6 types of PPE as compared to controls (OR=5.19-52.4, p<0.001, Table 2). Most notably, 44.4% of the cases reported that there was an inadequate supply of at least one of the PPE, as compared to 14.0% of the controls (OR=6.78, p<0.0011), among SARS cases, 26% reported 3 or more PPE items as being in inadequate supply as compared to 1.4% of the controls (OR=52.2, p<0.0001).

SARS-RELATED INFECTION CONTROL TRAINING AND KNOWLEDGE ACQUIRED

The univariate results indicated that 50% SARS cases did not receive any SARS infection control training (versus 28% of the controls, see Table 4). Those who underwent 2 or more hours of training (4.2% of cases and 25.2% of controls) were far less likely to have been infected with SARS (OR=0.03, p<0.0001). Of the SARS cases, 23.9% indicated that they did not understand the infection control measures, compared with 8.5% of the controls (OR=3.14, p=0.0065). There was a marginal statistically significant difference (OR=0.27, p=0.057) in the proportion who reported having received updated SARS information between cases (88.9%) and controls (96.5%).

VARIABLES RELATED TO PATIENT CARE

A higher but statistically non-significant percentage of the control group (73.4%) reported having direct contact with SARS patients as compared to the case group (62.5%). Three out of 72 cases (4.2%) and 7 out of 143 controls (4.9%) reported that they had no direct contact with "patients in general" (p>0.05). Having performed high-risk procedures on SARS patients and being seconded from another unit were not significantly associated with risk of SARS infection (see Table 4).

GENERAL COMPLIANCE WITH INFECTION CONTROL MEASURES AND PROBLEMS WITH PPE

There was no significant differences between the percentages of cases and controls who reported the following problems: general compliance problems, frequency of touching/adjusting the N95 mask, general problems with mask, problems with mask fit, problems with fogging of goggles. (see Table 4).

SOCIAL CONTACTS WITH SARS CASES

Approximately 23.6% of the SARS cases and 33.6% of the matched controls reported having social contact with someone who later turned out to be a SARS patient (p=0.1592) (see Table 4).

NUMBER OF PROBLEMS ENCOUNTERED

Seven problems were identified in the univariate analysis (for information about the 7 problems, see footnotes of Table 5) that were significantly associated with risk of SARS infection. An indicator variable was constructed by counting the number of problems encountered by the study participants. Almost all (98.6%) of the case group encountered at least one problem (versus 79.9% in the control group). The risk increases greatly with the number of problems encountered (OR= 44.2 for 3 or more problems, p<0.0001, see Table 5). Using a cut-off point of 2 or more problems to predict SARS infection, gives a sensitivity/specificity of 0.681 and 0.691 respectively.

MULTIVARIATE ANALYSIS

The results of the forward stepwise conditional logistic regression model using the above-mentioned 7 univariately significant variables as candidate variables, indicate that the perceived inadequacy of PPE supply (OR=4.27, 95% CI= 1.66-12.54,p=0.0028), SARS infection control training shorter than 2 hours or no training (OR=13.6, 95% CI=1.24-27.50, p=0.002) and inconsistent use of more than types of PPE when having direct contact with SARS patients (OR=5.06, 95% CI=1.91-598.92, p=0.02) were significantly and independently associated with SARS infection among hospital workers.

DISCUSSION

Breakthrough transmission was responsible for the SARS infection of the studied cases, as protective masks (primarily N95) had been used consistently by almost all of the cases. All workers were required to wear protective masks from March 12, 2003. The use of protective masks alone is, therefore, not sufficient to eliminate SARS transmission among hospital workers. Cases were less likely to have had direct contact with a SARS patient than controls, suggesting that direct contact with SARS patients was not necessary for breakthrough transmission to occur. It also suggests that modes of transmission other than droplets cannot be excluded. Consistent hand hygiene after contact with patients has almost been universal and hence, it was not a significant factor predicting SARS transmission in our context, although hand hygiene may still be a risk factor in situations when there was "no patient contact."

Data related to the 3 settings show that inconsistent use of gown, cap and goggles were all very strongly associated with breakthrough transmissions. It is hence important that PPE should be used consistently in all 3 settings. The high degree of collinearity in the use of the various types of PPE makes it difficult to ascertain which type of PPE is most important as a SARS countermeasure. Nevertheless, policy makers should be made aware that the supply of different types of PPE had often been seen as inadequate and it is one of the very significant risk factors identified. As inadequate knowledge of SARS infection control ("did not understand procedures") is also a strong risk factor for breakthrough transmission, SARS infection control training must not be overlooked. In-depth, thorough training (>=2 hrs) is required.

The findings eliminate a number of speculated risk factors which include: performing high-risk procedures on SARS patients, having social contacts with people who were later found to be SARS cases and experiencing various minor problems in using the mask. Performing high-risk procedures was not a significant factor, most likely due to a high degree of awareness and caution taken when performing these procedures with SARS patients.

It is found that those who encountered any one of the 7 identified problems had a greatly increased likelihood of contracting SARS. The number of problems encountered is a good predictor of SARS infection. It is recommendable to have health workers complete a checklist of these items after each day's work and the management should review these forms. No hospital staff should be permitted to be exposed occupationally to a risk of SARS infection before receiving adequate training or before they have obtained a thorough understanding of the infection control procedures. The results of the multivariate analysis show that infection control training, PPE use and perceived supply were independently associated with SARS infection risk among hospital workers.

The present study has a number of limitations. As a case-control study, it is subject to recall bias. However, the recall period was usually within one week as all the cases were interviewed while they were hospitalized. Another possible bias that may arise was that the case group may be attributing their infection to factors external to themselves (e.g. inadequate supplies) and the control group may be doing the opposite. Given that the odds ratios obtained were strongly significant and consistent with one another, it is unlikely that this form of bias could account for all of the observed differences. The study, however, has a relatively large sample size, a high response rate and having controlled for the exposure to other background confounding factors.

Hospital workers in Hong Kong have demonstrated commendable professionalism and courage in caring for SARS patients. It is incumbent on policy makers to ensure that they receive the highest standard of protection and training.

REFERENCES

1. WHO issues a global alert of cases of atypical pneumonia: Cases of severe respiratory illness may spread to hospital staff. World Health Organization, 2003. (Accessed May 23, 2003, at http://www.who.int/mediacentre/releases/2003/pr22/en/print.html.)

2. Latest figures on Severe Acute Respiratory Syndrome (as of May 31st 2003). Hong Kong Government, 2003. (Accessed May 31, 2003, at http://www.info.gov.hk/dh/diseases/ap/eng/infected.htm.)

3. Tomlinson B, Cockram C. SARS: experience at Prince of Wales Hospital, Hong Kong. Lancet 2003; 361 :1486-1487.

4. Seto WH, Tsang D, Yung RW, Ching TY, Ng TK, Ho M et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet 2003; 361:1519-1520.

5. McFadden D. Conditional Logit Analysis of Qualitative Choice Behavior. In: Zarembka, editor. Frontiers in Econometrics. New York: Academic Press, 1973: 105-142.

6. LogXact for Windows. [Computer program]. Version 4.1. Cambridge, MA: 2000.

Table 1. Percentages exposed to the risk of inconsistent use of different types of PPE in 3 clinical settings

Type of PPE	Control (n=143)	%	Case (n=72)	%	Matched OR (exact 95% CI)	p-value (exact)
N95 or Surgical mask						
Direct contact with SARS patients	0	0%	1	1.4%	2.00 (0.05, ∞)	0.6667
Direct contact with "patients in general" *	1	0.7%	2	2.8%	4.00 (0.21, 235.99)	0.5185
When there is "no patient contact" †	3	2.2%	4	5.7%	2.43 (0.41, 16.77)	0.4198
N95						
Direct contact with SARS patients	6	4.2%	7	9.7%	2.86 (0.70, 13.71)	0.1683
Direct contact with "patients in general" *	5	3.6%	3	4.2%	1.28 (0.16, 10.47)	1.0000
When there is "no patient contact" †	14	10.2%	12	17.1%	1.83 (0.72, 4.71)	0.2315
Goggles						
Direct contact with SARS patients	12	8.4%	23	31.9%	6.41 (2.49, 19.49)	<0.0001
Direct contact with "patients in general" §	7	5.1%	16	22.2%	6.93 (2.19, 28.85)	0.0003
When there is "no patient contact" ‡	19	13.9%	21	30.0%	3.50 (1.42, 9.47)	0.0046
Gown						
Direct contact with SARS patients	6	4.2%	15	20.8%	8.85 (2.46, 48.28)	0.0002
Direct contact with "patients in general" *	2	1.4%	12	16.7%	11.54 (2.56, 106.36)	0.0002
When there is "no patient contact" ‡	16	11.7%	19	27.1%	3.42 (1.38, 9.30)	0.0061
Gloves						
Direct contact with SARS patients	2	1.4%	11	15.3%	20.54 (2.96, 887.72)	0.0002
Direct contact with "patients in general" *	5	3.6%	7	9.7%	3.53 (0.77, 21.85)	0.1211
When there is "no patient contact" ‡	20	14.6%	19	27.1%	2.42 (1.05, 5.81)	0.0374
Cap						
Direct contact with SARS patients	8	5.6%	17	23.6%	7.30 (2.33, 30.21)	0.0001
Direct contact with "patients in general" *	5	3.6%	15	20.8%	12.81 (2.92, 116.75)	0.0001

When there is "no patient contact"[‡]	16	11.7%	22	31.4%	4.05 (1.68, 10.76)	0.0009
Number of equipment inconsistently used with direct contact with SARS patients[∥]						
0	129	90.2%	45	62.5%	1.00	
1-2	7	4.9%	13	18.1%	5.35 (1.79, 18.53)	0.0015
3+	7	4.9%	14	19.4%	7.84 (2.30, 34.83)	0.0003
Number of equipment inconsistently used with direct contact with "patients in general"[§,∥]						
0	127	92.0%	52	72.2%	1.00	
1-2	6	4.3%	8	11.1%	4.85 (1.01, 31.86)	0.0479
3+	5	3.6%	12	16.7%	10.83 (2.29, 102.60)	0.0007
Number of equipment inconsistently used when there was "no patient contact"[∥,¶]						
0	113	82.5%	46	65.7%	1.00	
1-2	6	4.4%	4	5.7%	1.56 (0.28, 7.97)	0.7721
3+	18	13.1%	20	28.6%	3.40 (1.37, 9.23)	0.0061

[*] Information on 4 controls missing

[†] Information on 4 controls and 2 cases missing

[‡] Information on 6 controls and 1 case missing

[§] Information on 5 controls missing

[∥] Information on 6 controls and 2 cases missing

[¶] Including N95, goggle, gown, gloves and cap

Table 2. Percentage with inconsistent hand hygiene

	Control (n=143)		Case (n=72)		Matched OR (exact 95% CI)	p-value (exact)
	n	%	n	%		
After direct contact with SARS patients	0	0%	2	2.8%	4.83 (0.38, ∞)	0.2222
After direct contact with "patients in general" *	2	1.4%	1	1.4%	1.00 (0.02, 19.21)	1.0000
When there was "no patient contact" †	3	2.1%	10	14.3%	6.38 (1.64, 36.17)	0.0044

* Information on 3 controls missing

† Information on 1 control and 2 case missing

Table 3. Percentages with perceived inadequacy of PPE supply and breakthrough SARS infection among hospital workers

Type of PPE	Control (n=143)		Case (n=72)		Matched OR (exact 95% CI)	p-value (exact)
	n	%	n	%		
Surgical mask	1	0.7%	14	19.4%	28.00 (4.26, ∞)	<0.0001
N95 mask	13	9.1%	20	27.8%	5.19 (1.95, 16.13)	0.0004
Gown	7	4.9%	19	26.4%	8.44 (2.77, 34.37)	<0.0001
Gloves	2	1.4%	12	16.7%	29.34 (4.79, ∞)	<0.0001
Goggles	5	3.5%	22	30.6%	19.81 (4.83, 174.55)	<0.0001
Cap	4	2.8%	21	29.2%	52.41 (9.08, ∞)	<0.0001
Any one of above as inadequate*	20	14.0%	32	44.4%	6.78 (2.86, 18.51)	<0.0001
Number of items identified to be inadequate *						
0	123	86.0%	40	55.6%	1.00	
1-2	18	12.6%	13	18.1%	3.25 (1.17, 9.80)	0.0209
3	2	1.4%	19	26.4%	52.24 (7.70, 2280.07)	<0.0001

* Including N95 mask, goggle, gown, gloves and cap

Table 4. Percentage distributions of variables related to training, patient care, social contact and mask compliance

	Control (n=143)		Case (n=72)		Matched OR (exact 95% CI)	p-value (exact)
	n	%	n	%		
Length of SARS infection control training						
None	40	28.0%	36	50.0%	1.00	
<2hrs	67	46.9%	33	45.8%	0.47 (0.18, 1.14)	0.1028
2hrs+	36	25.2%	3	4.2%	0.03 (0.001, 0.20)	<0.0001
Understood infection control measures*						
Yes	130	91.5%	54	76.1%	1.00	
No	12	8.5%	17	23.9%	3.14 (1.35, 7.73)	0.0065
Acquired updated information						
No	5	3.5%	8	11.1%	1.00	
Yes	136	96.5%	64	88.9%	0.27 (0.06, 1.04)	0.0574
High risk procedures with SARS patients†						
No	115	86.5%	60	83.3%	1.00	
Yes	18	13.5%	12	16.7%	1.22 (0.45, 3.14)	0.8061
Direct contact with SARS patients						
No/Not sure	38	26.6%	27	37.5%	1.00	
Yes	105	73.4%	45	62.5%	0.57 (0.28, 1.14)	0.1197
Direct contact with patients in general						
No/Not sure	7	4.9%	3	4.2%	1.68	1.000
Yes	136	95.1%	69	95.8%	(0.07, 117.74)	
Seconded from another unit						
No	77	53.8%	46	63.9%	1.00	

Yes	66	46.2%	26	36.1%	0.60 (0.29, 1.21)	0.1671
Social contact with SARS patients						
No/Not sure	95	66.4%	55	76.4%	1.00	
Yes	48	33.6%	17	23.6%	0.59 (0.28, 1.19)	0.1592
Frequency of touching the N95‡						
Never/occasional	108	76.6%	46	70.8%	1.00	
Most of the time/Always	33	23.4%	19	29.2%	1.32 (0.63, 2.74)	0.5205
General problems with mask§	68	48.6%	28	40.6%	0.66 (0.34, 1.27)	0.2407
Problems with mask fit‖	70	49.0%	33	47.8%	1.00 (0.51, 1.95)	1.0000
Problems with fogging of goggles ¶	75	52.8%	26	40.0%	0.61 (0.31, 1.17)	0.1520
Overall problems in general compliance **	69	50.0%	29	41.4%	0.58 (0.25, 1.33)	0.2264

* Information on 1 control and 1 case missing † Information on 10 controls direct contact with SARS patients missing

‡ Excluded 2 controls and 6 cases who did not use N95 mask; Information on 1 case missing

§ Excluded 1 case who did not use mask; information on 3 controls and 2 cases missing

‖ Excluded 1 case who did not use mask; information on 2 cases missing

¶ Excluded 3 cases who did not use goggle; information on 1 control and 3 cases missing

** Excluded 1 case who did not use any equipment; information on 5 controls and 1 case missing

Table 5: Percentage distribution of the number of problems encountered by the hospital worker†

Number of problems encountered*	Control n	Control %[2]	Control cumulative %	Case n	Case %[3]	Case cumulative %	Matched OR (exact 95% CI)	p-value (exact)
0	27	20.1%	20.1%	1	1.4%	1.4%	1.00	
1	65	48.5%	68.6%	21	30.4%	31.8%	8.47(1.37,∞)	0.0169
2	24	17.9%	86.5%	17	24.6%	56.4%	17.78(2.67,∞)	0.0010
≥3‡, §	18	13.4%	100.0%	30	43.5%	100.0%	44.15(7.02,∞))	<0.0001

* The 7 problems are: inconsistent use of at least 1 type of PPE when having contact with SARS patients, with "patients in general," when there was "no patient contact," when SARS infection control training was less than 2 hours, when the respondent reported not understanding SARS infection control procedures, when at least one PPE was perceived to be in inadequate supply in the 3 settings, and when hand hygiene was inconsistent when there was "no patient contact."

† Excluded 9 controls and 3 cases that had at least 1 missing entry on one of the problems encountered

‡ Percentages of the number of problems encountered in the control group: 3 problems (6.7%), 4 problems (4.5%), 5 (1.5%), 6 (0.7%), and 7 (0%)

§ Percentages of the number of problems encountered in the case group: 3 problems (10.1%), 4 (8.7%), 5 (13.0%), 6 (8.7%), and 7 (2.9%)