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Prevalence of subclinical infection and transmission of severe acute respiratory syndrome (SARS) in a residential care home for the elderly

一所安老院舍內嚴重急性呼吸系統綜合症的亞臨床感染患病率及傳染途徑

Objective. To ascertain the prevalence of subclinical severe acute respiratory syndrome–coronavirus (SARS-CoV) infection and study the transmission of SARS-CoV in a local outbreak at a residential care home for the elderly.
Design. Cross-sectional study.
Setting. A residential care home for the elderly in Hong Kong with a local outbreak of SARS.
Participants. Residents and staff in the residential care home who had contact with three patients with SARS (residents A and B, and staff C).
Main outcome measures. Blood samples were tested for total antibodies to SARS-CoV by immunofluorescence antibody test. The transmission of SARS was elucidated based on information from standardised questionnaires, and records of investigation and surveillance by the Department of Health.
Results. Among the 90 eligible residents, three died, one moved out, and 19 refused to participate. Of the 32 eligible staff, six refused to participate. None of the remaining 93 participants tested positive for antibody to SARS-CoV. Based on the chronological order, resident A might have transmitted infection to resident B and staff C. Sitting close to the bathroom doorway while resident A took a shower was the only contact of resident B with resident A. The only opportunity for staff C to have contact with body fluids/excreta of resident A was in the handling of rubbish from the resident's room.
Conclusion. Subclinical SARS-CoV infection was rare in a residential care home for the elderly with an outbreak of SARS. Nonetheless the close working and living conditions for staff and residents in such a home may facilitate transmission of SARS despite vigilant precautionary measures.

目的：研究一所曾經有嚴重急性呼吸系統綜合症(沙士)爆發的安老院舍內，沙士冠狀病毒的亞臨床感染患病率及傳染途徑。
設計：橫斷面研究。
安排：香港一所曾經有沙士爆發的安老院舍。
參與者：安老院舍內曾與三名沙士患者(院友甲、院友乙及職員丙)接觸的院友及職員。
主要結果測量：收集血液樣本，及以抗體螢光染色抗體測試檢驗血液樣本的沙士冠狀病毒全部抗體。根據標準問卷及香港特別行政區衞生署調查及監測紀錄的資料，分析沙士的傳染途徑。
結果：90名院友中，3名死亡，1名遷出，另19名拒絕參與此研究。32名職員中，6名拒絕參與。結果在93名參與者中沒有人對沙士冠狀病毒抗體測試呈陽性反應。根據時間上的先後次序，可能是院友甲把病毒傳染給院友乙及職員丙。院友乙在院友甲淋浴時坐在接近浴室門口處是她們的唯一接觸。而處理院友甲房間的垃圾是職員丙唯一有機會接觸到院友甲的體液或排泄物的場合。
結論：於曾經有沙士爆發的安老院舍內，亞臨床沙士冠狀病毒感染是罕見的。儘管一所安老院舍採取了嚴緊的預防措施，由於職員及院友在工作及居住上有緊密接觸，沙士的傳染仍可發生。

Key words:
Aged;
Disease transmission;
Homes for the aged;
Seroepidemiologic studies;
Severe acute respiratory syndrome

關鍵詞：
長者；
疾病傳染；
安老院舍；
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Introduction

In 2003, an epidemic of severe acute respiratory syndrome (SARS) in Hong Kong infected 1755 (0.026%) people of a 6.7 million population.[1] Subclinical SARS-coronavirus (SARS-CoV) infection has been reported in high-risk groups: 2.3% of health care workers in SARS wards and 0.19% asymptomatic close contacts of SARS patients demonstrated a positive serological response.[2,3] Subclinical infection also occurred in 0.8% of non-pneumonic paediatric in-patients and 0.8% of healthy blood donors.[4]

Transmission of SARS-CoV is not fully understood. In a hospital-based study, the protective role of surgical mask supported a mode of droplet transmission.[5] Nonetheless the durable viability of the virus at room temperature suggests that transmission through fomites is possible.[6] The investigation of a SARS outbreak in a housing estate in Hong Kong led to the postulation that virus-containing droplets could have been drawn from unsealed floor drain by bathroom exhaust fan.[7,8] The correlation of the temporal and spatial distributions of cases with the three-dimensional spread of a virus-laden aerosol plume lent support to the evidence of airborne transmission.[9]

During the SARS epidemic in Hong Kong, both residents and staff at some residential care homes for the elderly (RCHEs) were infected. At the time of the outbreak, approximately 56 000 elderly were resident in 760 RCHEs. Among these, 72 (0.13%) residents from 51 residential care homes were diagnosed with SARS. Most cases from the latter RCHEs were sporadic; 38 (75%) had only one affected resident. Nonetheless, 10 (14%) of the 72 infected residents were responsible for or affected by SARS transmission within only six RCHEs and 57 (79%) of these 72 residents died,[10] which was a substantially higher fatality rate than for SARS in the general population (17%).[1] Close living and working conditions for staff and residents in RCHEs and the presence of both physically and mentally disabled residents make infection control measures difficult to enforce.[11] Group activities facilitate contact between residents and staff from different floors or regions of an institution. Manpower constraints and shared toilet/bathing facilities increase the opportunity for cross-contamination. All these factors increase the risk of SARS outbreaks in RCHEs. Despite this, local spread of SARS was evident in only six RCHEs.[10] It was therefore possible that subclinical cases might have occurred: residents may have been asymptomatic or exhibited mild symptoms that did not fulfil the clinical criteria for SARS. The status of such cases of subclinical SARS-CoV infection in RCHEs remains unclear. Due to the high-risk environment, more information about the mode of SARS-CoV spread in RCHEs is crucial.

Thus, the objective of this study was to ascertain the seroprevalence of SARS-CoV infection in RCHEs. Case studies of a local outbreak in an RCHE are also reported.

Methods

The study was conducted in an RCHE with local spread of SARS that infected two residents (residents A and B) and one staff (staff C). All residents and staff who were in the home between the period 10 days prior to symptom onset of the first SARS case and the day when the last SARS case left the institution were invited to participate. Informed written consent was obtained from participants and approval for the study was obtained from the Ethics Committee of the Department of Health of the Hong Kong Special Administrative Region (HKSAR).

Blood samples from all subjects were tested for total antibodies to SARS-CoV by immunofluorescence antibody test in the Public Health Laboratory Centre of the Department of Health of HKSAR. The same antibody test was used to diagnose SARS during the SARS outbreak in Hong Kong. Cell smear infected with SARS-CoV was used as antigen. For the purpose of screening, serum of subjects was applied onto the smears at an initial dilution of 1:25, and anti-human antibody conjugate was used to detect the presence of SARS-CoV antibody. For any specimen that yielded a positive result on screening, a series of dilutions was made to determine the endpoint titre, and the specimen subjected to confirmation by a neutralisation test. Most blood samples were collected in early July 2003; approximately 10 weeks after the last SARS case left the institution. A standardised questionnaire was completed for participants through face-to-face interview with staff of the RCHE by trained interviewers (from Elderly Health Services of the Department of Health of HKSAR). The following information was collected: (1) for residents and staff: demographic data and symptoms reported from 10 days before symptom onset of the first SARS case to 10 days after the last SARS case left the institution; (2) for residents: health status, mobility, need for nursing care, and usual activities; and (3) for staff: job title, nature of duties, and working area.

Most interviews were conducted in late July 2003. Symptoms that might suggest subclinical SARS-CoV infection included fever, chills, malaise, headache, myalgia, sore throat, cough, shortness of breath, vomiting, and diarrhoea. Relevant information on SARS status, contact history of residents and staff with SARS cases, symptom development, and infection control measures were also retrieved from the record of investigation and surveillance of the Department of Health. The laboratory results of the three SARS cases were retrieved from hospital records.

Results

Seroprevalence of severe acute respiratory syndrome–coronavirus infection

Ninety residents and 32 staff were eligible for the study. Three residents had died of unrelated causes, more than 4 weeks after the last SARS case left the institution. One resident had moved out before the study was conducted.

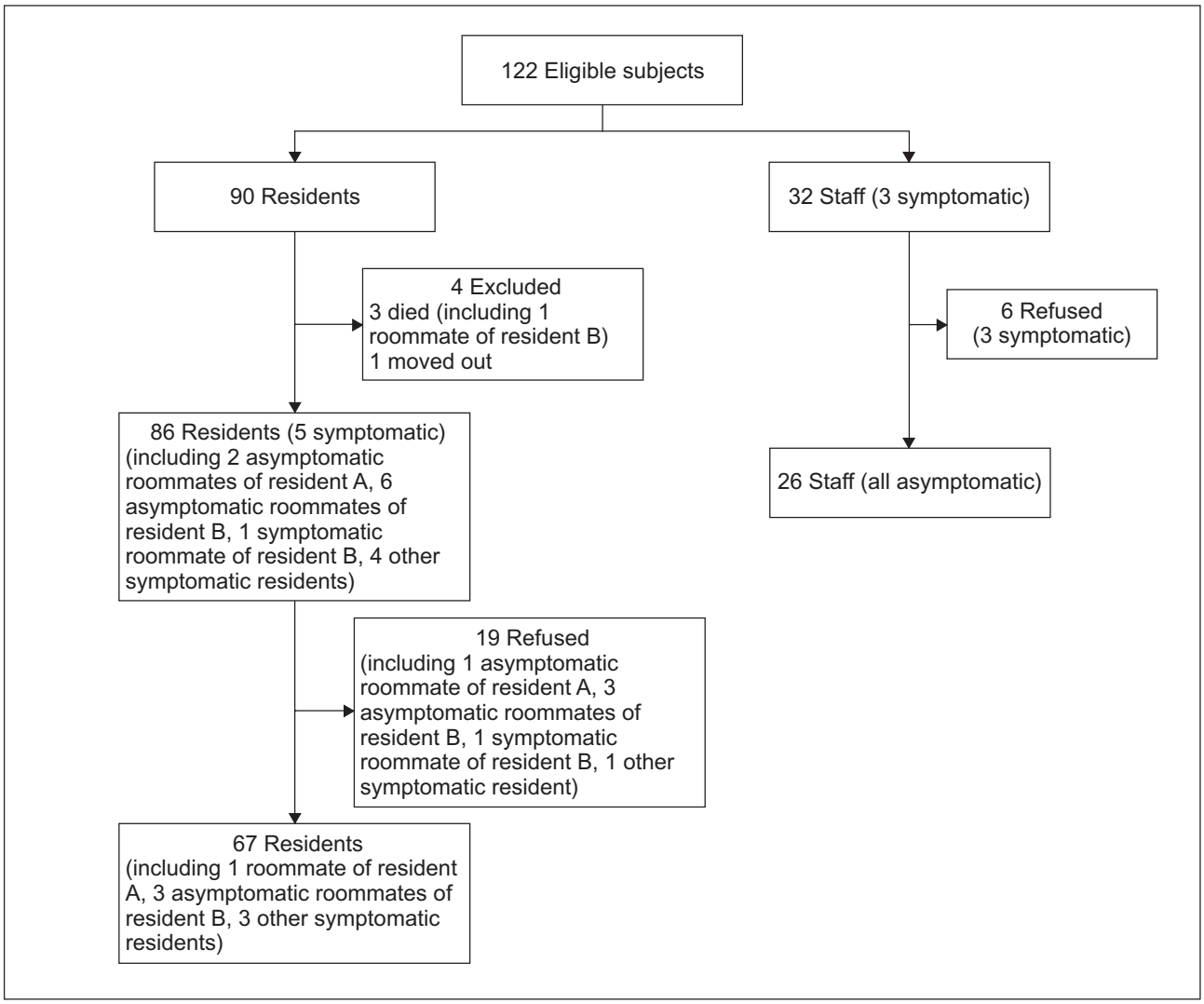

Fig 1. Residents and staff participating in the study in the residential care home for the elderly

Table 1. Symptoms of symptomatic residents and staff

Symptom	No. of residents, n=5	No. of staff, n=3
Fever	1	1
Chills	0	0
Malaise	2	1
Headache	2	0
Myalgia	0	1
Sore throat	0	2
Cough	0	1
Shortness of breath	0	0
Vomiting	0	0
Diarrhoea	2	0

Five (6%) of the remaining 86 residents and three (9%) of the 32 eligible staff had experienced symptoms suspicious of subclinical SARS-CoV infection during the study period. One of these symptomatic residents was a roommate of resident B. Nineteen residents and six staff refused to participate. They included two (including the symptomatic roommate of resident B) of the five symptomatic residents, one of the two roommates of resident A, and three of the six asymptomatic roommates of resident B. Unfortunately, none of the three staff who had symptoms were willing to participate in the study. The remaining 67 (78%) residents and 26 (81%) staff, together with the three SARS cases (resident A, resident B, and staff C) were studied (Fig 1). Symptoms of the five symptomatic residents and the three symptomatic staff are summarised in Table 1. Most residents were over 75 years old and ambulatory (Table 2). Most staff participants had close contact with residents and/or were exposed to their body fluids/excreta (Table 3). None of the 93 participants (67 residents + 26 staff) were positive for antibody to SARS-CoV by the immunofluorescence antibody test.

Illustration of three severe acute respiratory syndrome cases

The RCHE consisted of two floors and was under renovation at the time of the SARS outbreak. A total of 92 residents (including residents A and B) lived in 16

Table 2. Characteristics of residents who participated in the study

Characteristic	No. of residents, n=67
Age (years)	
65-75	7 (10%)
76-85	32 (48%)
≥86	28 (42%)
Sex	
Male	14 (21%)
Female	53 (79%)
Mobility	
Ambulant	62 (93%)
Chair-bound	4 (6%)
Bed-bound	1 (1%)
Group activities with other residents	
Yes	60 (90%)
No	7 (10%)
Habit of going out	
Yes	53 (79%)
No	14 (21%)

Table 3. Characteristics of staff who participated in the study

Characteristic	No. of staff, n=26
Age (years)	
31-50	18 (69%)
≥51	8 (31%)
Sex	
Male	4 (15%)
Female	22 (85%)
Post	
Superintendent	1 (4%)
Vice-superintendent	1 (4%)
Nurse	2 (8%)
Personal care worker	10 (38%)
Workman	4 (15%)
Cook	3 (12%)
Social worker	1 (4%)
Welfare worker	2 (8%)
Clerk	1 (4%)
Driver	1 (4%)
Nature of duties	
Nursing care	14 (54%)
Assistance in daily activities	12 (46%)
Cleaning work	19 (73%)
Fixed working area	
Yes	6 (23%)
No	20 (77%)

permanent rooms and two temporary rooms (rooms A and B). Each permanent room had an en-suite bathroom. The two temporary rooms were located on the ground floor (Fig 2) and were adjacent to each other; they were separated by a high partition that rose to within 2 feet of the ceiling and had no en-suite bathroom. Residents A and B lived in rooms A and B, respectively. All staff took droplet and contact precautions when caring for residents during the study period.

Resident A was discharged back to the institution on 15 April 2003 following hospitalisation for congestive heart failure. As a precautionary measure against SARS, she was quarantined in her room following discharge from the hospital. Nevertheless two other residents resided in room A with their beds separated from resident A by a wardrobe and a screen. Resident A did not have any respiratory symptoms on return from the hospital. She was chair-bound and did not leave the room except for using the bathroom opposite (room 3). She wore a surgical mask during the transfer and the bathroom was disinfected immediately after she had taken a shower. She generally used a commode for toileting but required incontinence nappies at other times. Her excreta were disposed into the toilet of room 3, and nappies into the rubbish bin of room A. The toilet bowl was disinfected immediately following disposal of excreta. On the night of 25 April 2003, resident A suddenly developed fever and diarrhoea and was immediately admitted to hospital. The diagnosis of SARS was confirmed on 30 April 2003 and investigation revealed that she had probably contracted the disease during her stay in the original hospital in which there was a SARS outbreak.

Resident B was also chair-bound. During the 10 days prior to symptom onset, she had not left the RCHE, nor had she received any visitors. She did not use the bathroom in room 3 during the study period. However, she was brought to sit in the vacant area of room 3 before and during mealtime every day, and remained there for a while after finishing her meal. Her seat was positioned several feet directly outside the doorway of the bathroom in room 3. She had sat there before breakfast at the same time when resident A used the bathroom in room 3. This was the only occasion when resident B had been near resident A during the relevant period. Resident B became symptomatic on 30 April 2003 and was hospitalised on the same day.

Staff C was a domestic worker responsible for cleaning work that included handling and disposal of rubbish. The only contact she had with the body fluids/excreta of resident A was through emptying the rubbish bins of room A in which resident A's nappies were disposed. She had no history of direct contact with resident A. Staff C had been on leave since 28 April 2003 and paid a short visit to the institution for a staff meeting on 1 May 2003. She developed symptoms on 2 May 2003 and was admitted to hospital on 6 May 2003. Investigation revealed no definite history of exposure to other SARS cases during the 10 days prior to symptom onset. Figure 3 summarises the sequence of events in the institution for all three SARS cases.

Discussion

Our study is the first seroprevalence survey to investigate subclinical SARS-CoV infection in an RCHE. Despite the high-risk setting, none of the participants was positive for SARS-CoV antibodies. Although the response rate (76%) for participation in the study was satisfactory, a significant proportion of those with symptoms and roommates of infected residents refused to participate. This may be due to the fear of being diagnosed and stigmatised for having SARS. Thus, non-participation of such individuals may have

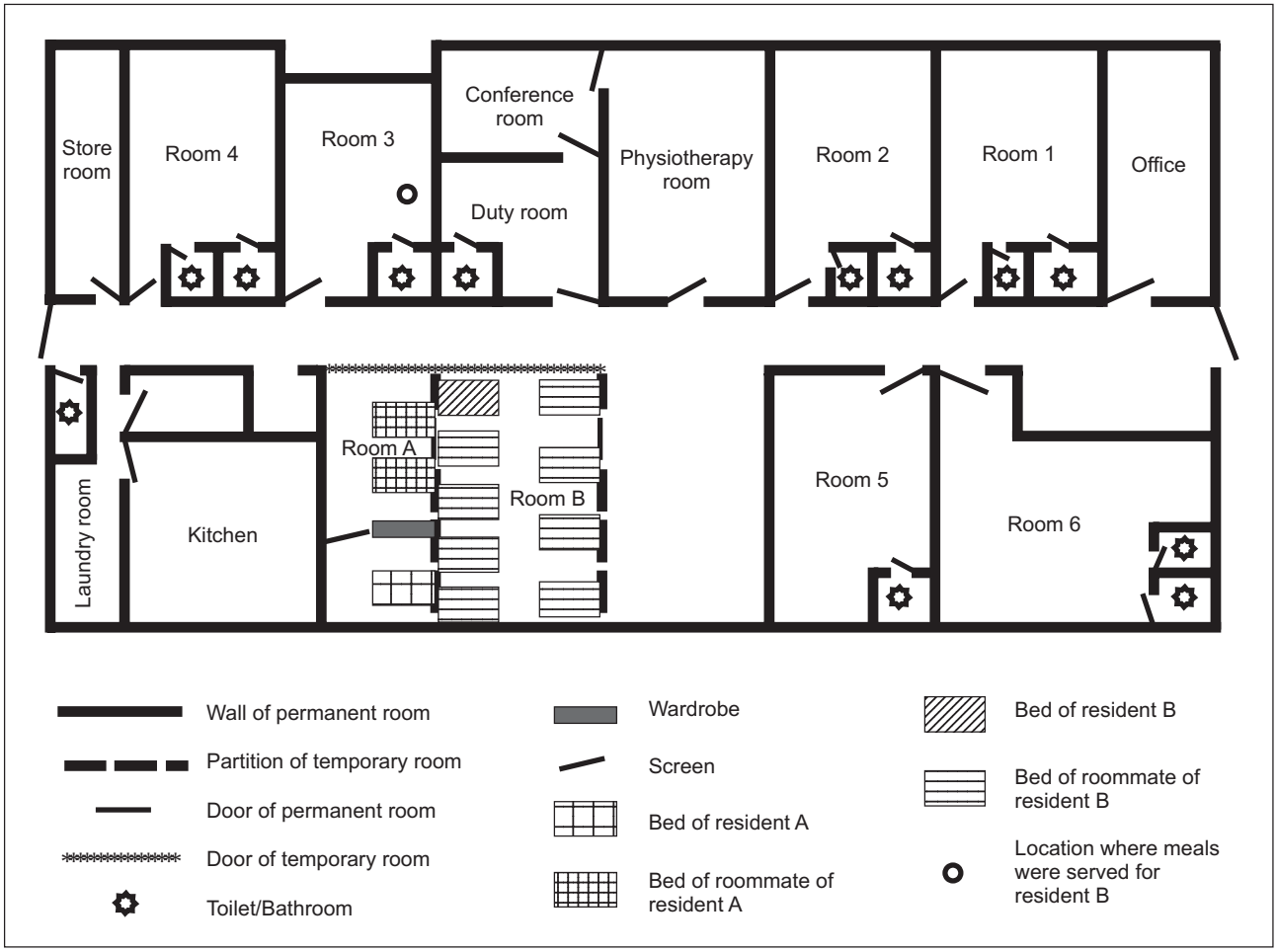

Fig 2. Ground floor plan of the RCHE

led to an underestimation of seroprevalence. Finding of such low seroprevalence may also be attributed to the precautionary measures taken at the RCHE to prevent contact and droplet transmission. Notwithstanding these arguments, subclinical SARS-CoV infection appears to be rare in an RCHE during the SARS outbreak. This is also consistent with other seroprevalence studies in high-risk populations.[2,3,12,13]

Based on the chronological order of events and contact history, SARS might have been transmitted from resident A to both resident B and staff C, despite the short duration of resident A's stay in the RCHE after symptom onset. Furthermore, the only occasion on which resident B was exposed to resident A was the brief period spent sitting at the doorway of the bathroom where resident A took her bath; and the only exposure of staff C to resident A was in the handling of rubbish from room A. Absence of a sink and toilet facilities in room A precluded prompt disinfection procedures and probably increased the opportunity for transmission through fomites. In addition, despite the implementation of precautionary measures in the RCHE, most staff may have received only minimal training in infection control. Lapses in infection control measures and cross-contamination by staff and residents might account for the transmission observed. It appeared unlikely that resident B, residing in a different room to resident A, contracted SARS from resident A with such contact history while resident A's roommates were not infected. It is possible there exists a mode of transmission peculiar to the RCHE setting that persists despite the precautions taken. The last exposure of resident B to resident A was at the doorway of the bathroom on the morning of 25 April 2003 (ie before resident A became symptomatic that night). The elderly often have inconspicuous symptoms of infection, and atypical presentation of SARS has also been reported in a geriatric patient.[14] Residents of RCHEs also had less prominent symptoms of SARS than elderly patients in the community.[10] It is therefore possible that resident A actually had indistinct symptoms soon after her discharge from the first hospital that were not recognised. Conceivably, the two symptomatic residents and the three symptomatic staff refusing to participate in this study could also have transmitted SARS if they had subclinical infection.

This study has several limitations. First, there is substantial variation in the environmental setting, nursing support, and hygiene level in different RCHEs, such that the seroprevalence of subclinical SARS-CoV infection in the RCHE under study might have been low due to

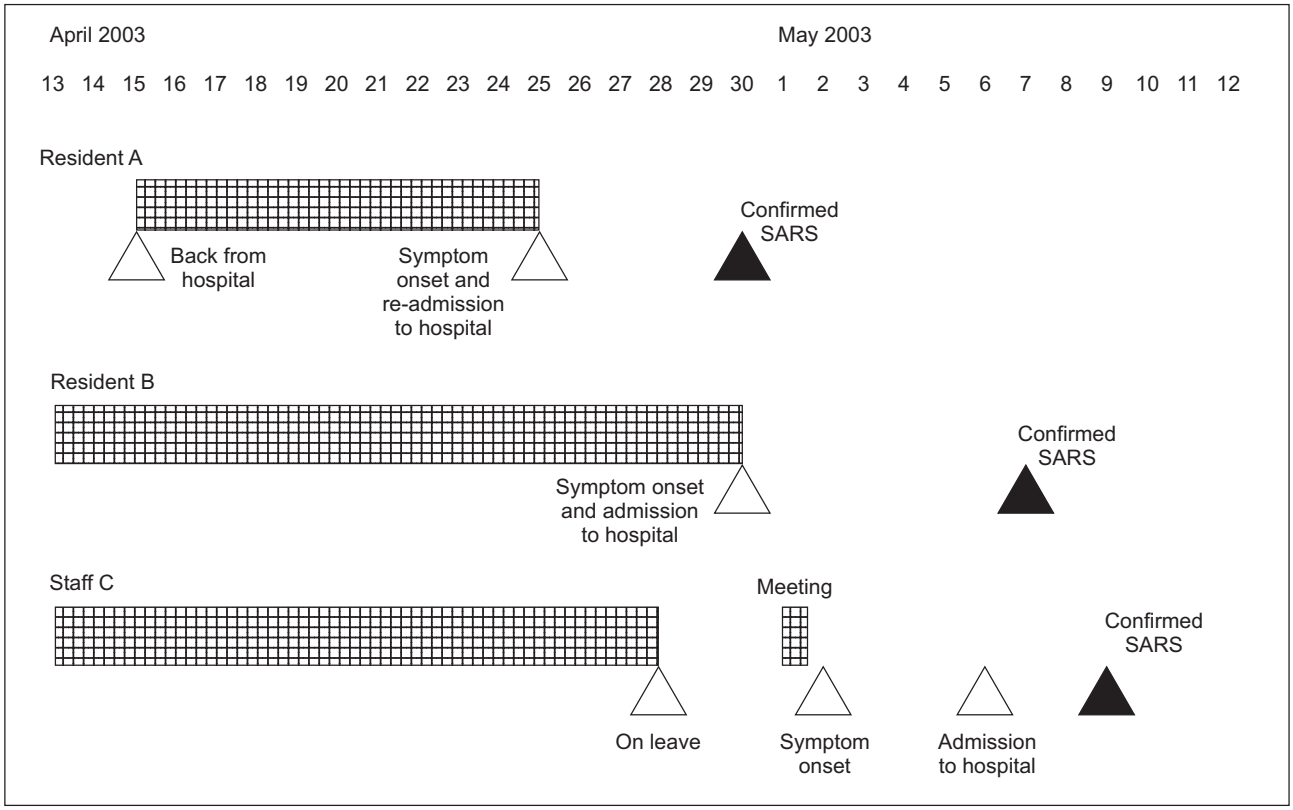

Fig 3. Sequence of events in the residential care home for the elderly

adoption of more stringent infection control measures. Second, a few high-risk residents and staff in this RCHE did not participate in our study. These subjects were more likely to have tested positive, and in them the possibility of subclinical infection, albeit rare, cannot be excluded. Although symptom development and daily activities of the residents and staff duties were recorded comprehensively, missing data as well as recall bias could not be eliminated owing to the retrospective nature of this study. As our postulations were based primarily on circumstantial evidence such as temporal and spatial relationships, further study is necessary to confirm our observations.

In this study, subclinical SARS-CoV infection was rare in an RCHE during the SARS outbreak. Despite vigilant precautionary measures, transmission of SARS through fomites remains possible. Further studies to explore the mode of spread of SARS in the high-risk setting of RCHEs are warranted.

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References

1. Latest figures on 2003 severe acute respiratory syndrome outbreak (as at 19 January). HKSAR Government website: http://www.info.gov.hk/info/sars/eindex.htm. Accessed 27 Apr 2004.
2. Ip M, Chan PK, Lee N, et al. Seroprevalence of antibody to severe acute respiratory syndrome (SARS)-associated coronavirus among health care workers in SARS and non-SARS medical wards. Clin Infect Dis 2004;38:e116-8.
3. Leung GM, Chung PH, Tsang T, et al. SARS-CoV antibody prevalence in all Hong Kong patient contacts. Emerg Infect Dis 2004;10:1653-56. Erratum in: Emerg Infect Dis 2004;10:1890.
4. Woo PC, Lau SK, Tsoi HW, et al. Relative rates of non-pneumonic SARS coronavirus infection and SARS coronavirus pneumonia. Lancet 2004;363:841-5.
5. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). Lancet 2003;361:1519-20.
6. First data on stability and resistance of SARS coronavirus compiled by members of WHO laboratory network. WHO website: http://www.who.int/csr/sars/survival_2003_05_04/en/. Accessed 27 Apr 2004.
7. Outbreak of severe acute respiratory syndrome (SARS) at Amoy Gardens, Kowloon Bay, Hong Kong: main findings of the investigation; 17 April 2003. HKSAR Government website: http://www.info.gov.hk/info/sars/pdf/amoy_e.pdf. Accessed 27 Apr 2004.
8. World Health Organization Regional Office for the Western Pacific. Environmental health team reports on Amoy Gardens. 2003. HKSAR Government website: http://www.info.gov.hk/info/sars/who-amoye.pdf. Accessed 27 Apr 2004.

9. Yu IT, Li Y, Wong TW, et al. Evidence of airborne transmission of the severe acute respiratory syndrome virus. N Engl J Med 2004; 350:1731-9.
10. Lam R, Kong KC, Li T, Chan WM, Tsang T. Epidemiology of SARS in old aged home residents in Hong Kong. Proceedings of the Conjoint Annual Scientific Meeting of Hong Kong College of Community Medicine and Hong Kong College of Family Physicians: Preparing for public health crisis; 2004 Apr 18; Hong Kong. Abstract FP4.
11. Wong WY, Chan WM. A survey on the infection control practice in residential care homes for the elderly in Hong Kong. Proceedings of the Conjoint Annual Scientific Meeting of Hong Kong College of Community Medicine and Hong Kong College of Family Physicians: Preparing for public health crisis; 2004 Apr 18; Hong Kong. Abstract FP3.
12. Chan PK, Ip M, Ng KC, et al. Severe acute respiratory syndrome-associated coronavirus infection. Emerg Infect Dis 2003;9:1453-4.
13. Yu WC, Tsang TH, Tong WL, et al. Prevalence of subclinical infection by the SARS coronavirus among general practitioners in Hong Kong. Scand J Infect Dis 2004;36:287-90.
14. Tee AK, Oh HM, Hui KP, et al. Atypical SARS in geriatric patient. Emerg Infect Dis 2004;10:261-4.