

ORIGINAL ARTICLE

Epidemiologic Study and Containment of a Nosocomial Outbreak of Severe Acute Respiratory Syndrome in a Medical Center in Kaohsiung, Taiwan

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OBJECTIVE. We conducted an epidemiologic investigation at the beginning of a nosocomial outbreak of severe acute respiratory syndrome (SARS) to clarify the dynamics of SARS transmission, the magnitude of the SARS outbreak, and the impact of the outbreak on the community.

METHODS. We identified all potential cases of nosocomially acquired SARS, linked them to the most likely infection source, and described the hospital containment measures.

SETTING. A 2,300-bed medical center in Kaohsiung, Taiwan.

RESULTS. A total of 55 cases of SARS were identified, and 227 hospital workers were quarantined. The index patient and neighboring patients were isolated. A chest physician team reviewed medical charts and chest radiographs and monitored the development of SARS in patients staying in the ward. The presence of underlying lung disease and immunocompromise in some patients made the diagnosis of SARS difficult. Some cases of SARS were diagnosed after the patients had died. Medical personnel were infected only if they cared for patients with unrecognized SARS, and caretakers played important roles in transmission of SARS to family members. As the number of cases of nosocomial SARS increased, the hospital closed the affected ward and expedited construction of negative-pressure rooms on other vacated floors for patient cohorting, and the last case in the hospital was identified 1 week later.

CONCLUSIONS. Timely recognition of SARS is extremely important. However, given the limitations of SARS testing, possible loss of epidemic links, and the nonspecific clinical presentations in hospitalized patients, it is very important to establish cohorts of persons with low, medium, and high likelihoods of SARS acquisition. Rapid closure of affected wards may minimize the impact on hospital operations. Establishment of hospitals dedicated to appropriate treatment of patients with SARS might minimize the impact of the disease in future epidemics.

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Shortly after the first patient with severe acute respiratory syndrome (SARS) in Taiwan was identified on February 14, 2003,¹ a SARS epidemic involving approximately 30 patients developed in northern Taiwan and rapidly spread to the southern end of the island.² In late April 2003, a large nosocomial outbreak of SARS occurred in Chang Gung Memorial Hospital (CGMH-KS) in Kaohsiung (the largest city in southern Taiwan) after the admission of a patient with unrecognized SARS. CGMH-KS is a 2,300-bed facility serving as a primary care and tertiary care referral medical center to the city of Kaohsiung and the surrounding area. The rapid development of the SARS

outbreak in this large and densely populated facility posed a substantial threat to other hospitalized patients, to staff, and to the community. An epidemiologic investigation was conducted at the beginning of the outbreak to clarify the dynamics of SARS transmission, the magnitude of the SARS outbreak, and the impact of the outbreak on the community. We report the results of this investigation and the measures taken by the hospital to combat the nosocomial outbreak of SARS. This investigation provides valuable information about potential causes of nosocomial transmission of SARS, as well as possible measures to contain future hospital outbreaks.

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METHODS

The investigation involved identifying all potential cases of nosocomially acquired SARS and linking these cases to their most likely source. All patients who had been treated at CGMH-KS since April 26, 2003, were contacted to obtain information regarding their clinical status and the status of those in close contact with them. Our database included (1) patients who our hospital reported to the government health department as having SARS, (2) patients who visited our emergency department on or after April 26, 2003, (3) patients (all of whom were contacted by telephone) who were placed under home quarantine and had been released from our hospital since April 26, (4) patients (all of whom were identified and contacted through the database provided by the Bureau of National Health Insurance, Taiwan) who had stayed or were staying at other hospitals but had a history of discharge from our facility since the SARS outbreak, and (5) patients with SARS who were described by the news media as having had a recent admission to CGMH-KS.

The diagnosis of SARS in patients in this outbreak was made on the basis of consensus of the hospital's SARS Team, which was composed of chest physicians, infectious diseases specialists, senior internists, and radiologists. The criteria for making a diagnosis of SARS were based on the World Health Organization definitions issued in late March 2003.³ SARS cases were linked to one another through the evaluation of information collected from personal interviews and chart reviews. Cases were considered to have a strong epidemiologic relationship if the affected patients shared a known close contact with a SARS-affected individual or if the case occurred after a high-risk procedure (Table 1). Cases were considered to have a weak epidemiologic relationship if the affected patients were temporally and spatially related but did not share either a known close contact with a SARS-affected individual or a history of brief contact with multiple persons with SARS.

TABLE 1. Contacts and Procedures Considered High-Risk for Transmission of Severe Acute Respiratory Syndrome (SARS)

Contact between SARS-affected patients and/or roommates
Contact between a main caretaker and a SARS-affected patient
Close household contact between family members and SARS-affected patients
Close household contact between family members and SARS-affected caretaker
High-risk procedure or effect of procedure
Endotracheal intubation
Insertion of nasogastric tube
Endotracheal extubation
Generation of aerosols
Suction of respiratory excreta
Chest physical therapy
Handling remains of patients who died of SARS

Serum specimens from 15 healthcare workers who survived SARS and from 115 asymptomatic healthcare workers who worked in CGMH-KS during the same period were obtained 1-3 months after the nosocomial outbreak for detection of antibody against SARS-associated coronavirus by enzyme-linked immunosorbent assay (ELISA). Detergent-extracted and γ -irradiated Vero E6 cells infected with SARS coronavirus were used as ELISA antigens. Serum specimens diluted at a ratio of 1 : 10 were separately added to different ELISA plates. Goat anti-human IgG antibody conjugated with horseradish peroxidase (DAKO) was added for enzymatic reaction, and *o*-phenylenediamine was used as a substrate. Under light with a wavelength of 450 nm, the cutoff of optical density for detection of SARS coronavirus IgG by ELISA was 0.150.

RESULTS

Description of the Outbreak

An index patient with initially unrecognized SARS was admitted to chest ward 11A on April 26, 2003, four days before SARS was identified (on April 30). Measures to prevent the spread of SARS in the hospital and an investigation of the epidemic were immediately started. Between April 26 and May 26, 2003, a total of 55 cases of SARS (52 probable SARS and 3 suspected SARS) were identified. These cases involved 16 hospitalized patients, 19 family members, 3 employed caretakers, 1 morgue worker, and 16 medical personnel (1 attending physician, 3 resident physicians, 1 intern, 2 respiratory therapists, and 9 nurses). A total of 227 hospital workers were quarantined. An epidemic curve of this outbreak is presented in Figure 1. These patients are numbered chronologically according to the date of onset of signs and symptoms suggestive of SARS. The exact date of onset of superimposing SARS in patient 10 was not clear because of persistent fever due to bacterial pneumonia, and therefore the fifth day after exposure to the infection source (ie, the mean incubation duration of SARS in this series) was estimated to be the SARS onset date. Patient 1 refers to the index patient. The spatial distribution and the possible epidemiologic links between patients are shown in Figure 2. Three patients (patients 8, 24, and 40) in ward 12A, where patients with a variety of internal illnesses (including pulmonary disease) were hospitalized, were identified as having suspected or probable SARS. A number of nurses from ward 12A also worked on ward 11A during this period, and each could have been a source of infection for patients in ward 12A.

One resident doctor (patient 12) died in this SARS outbreak. Twelve (80%) of the 15 healthcare workers who survived the nosocomial outbreak of SARS were serologically positive for SARS coronavirus IgG 1-3 months later, whereas 115 asymptomatic healthcare workers who worked in CGMH-KS during the same period were serologically negative. Of note, in this series some cases of SARS were diagnosed at postmortem examination, medical personnel were infected

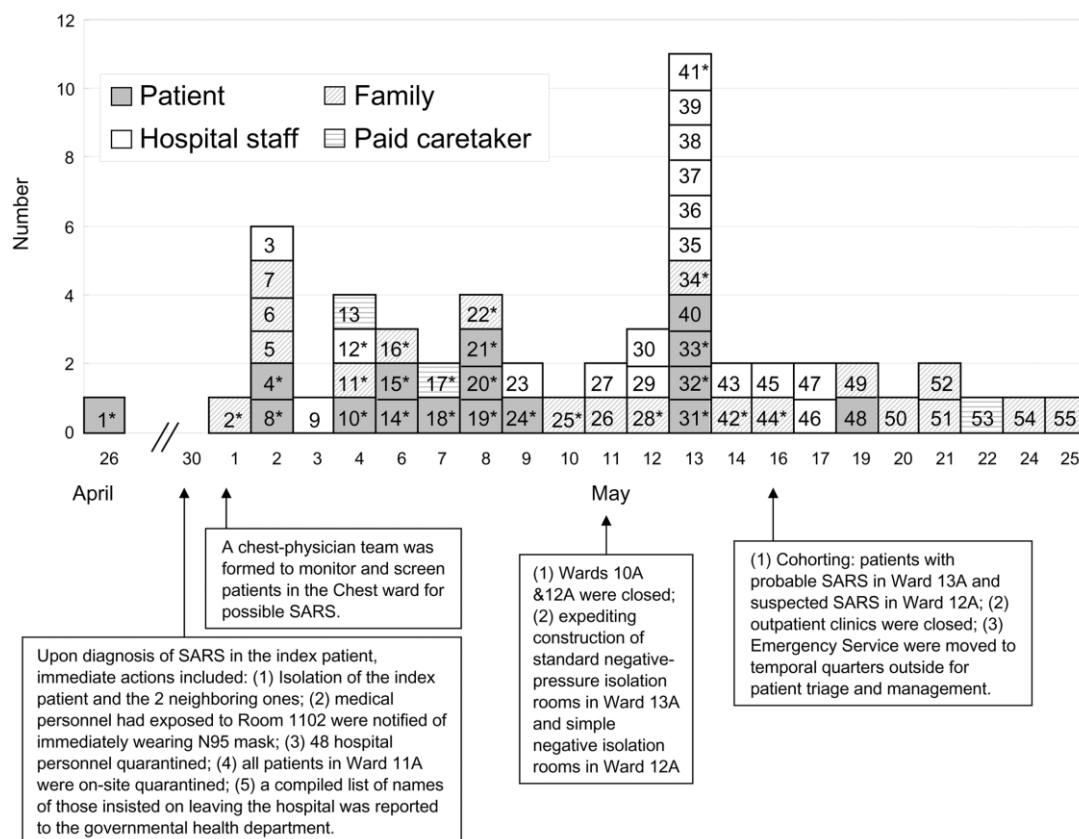


FIGURE 1. Epidemic curve of the nosocomial outbreak of severe acute respiratory syndrome (SARS) at Chang Gung Memorial Hospital (Kaohsiung, Taiwan) and timing of implementation of important infection control measures. Patients are numbered chronologically according to the date of onset of signs and symptoms suggestive of SARS. The index patient was admitted on April 26, 2003. Patients labeled with an asterisk (*) died.

only if they cared for patients with unrecognized SARS, and caretakers played important roles in transmission of SARS to family members.

Initially Unrecognized Cases of SARS

Index patient. A 52-year-old febrile woman visited our emergency department on April 26, 2003, with a chief complaint of pain in the left flank. She had a history of urolithiasis but denied receiving recent treatment at any hospital. Auscultation revealed rales over the lower half of her left hemithorax, and a chest radiograph showed consolidation in the left lower lung field. Because her SARS exposure history was unavailable, the patient was not placed in isolation, in accordance with the hospital's policy. The patient received a diagnosis of pneumonia and was admitted to room 1102 in ward 11A (a chest ward for patients with severe respiratory diseases), and amoxicillin-clavulanate was administered. The patient experienced progressively worsening dyspnea, and during the evening of April 28, she was intubated for mechanical ventilatory support by an on-duty resident physician,

intern, and nurse. On April 30, an infectious diseases specialist was consulted for analysis of the patient's unremitting fever. After reviewing the details of this case, the patient's history was further analyzed. The patient's sister disclosed that the patient had received treatment for her flank pain on April 19 and 23 at a hospital in Taipei, which had recently been evacuated and closed because of a nosocomial outbreak of SARS. A presumptive diagnosis of probable SARS was therefore made, which was subsequently confirmed by reverse-transcriptase polymerase chain reaction and real-time polymerase chain reaction analysis for the novel SARS coronavirus.⁴

Other patients. Three patients (patients 4, 10, and 18) received a diagnosis of probable SARS and 1 (patient 14) of suspected SARS after death, following retrospective review of their medical charts and chest radiographs (Table 2). The common factor found in these patients was an underlying immunocompromised state and chronic lung disease. These patients all had copious purulent excretion in their airways, leading to chronic respiratory distress, which, in turn, masked

superimposed SARS. Characteristics of these initially unrecognized SARS cases are summarized in Table 2.

Outbreak of SARS Among Hospital Staff

A total of 16 hospital staff developed SARS in this epidemic. Of the on-duty medical personnel caring for the index patient, the nurse (patient 3) developed probable SARS on May 2, whereas the intern (patient 9) and the resident physician (case 12) developed probable SARS on May 3 and May 4, respectively. The resident physician died of multiorgan failure on May 16. These 3 medical personnel had been involved in endotracheal intubation, respiratory excreta suction, and nasogastric tube insertion for the index patient on April 28; because SARS was not initially suspected, staff members wore gloves and surgical masks instead of putting on full personal protective equipment, which includes N95 masks, head covers, goggles, gloves, and gowns.⁵

Identification of additional cluster cases of SARS among medical personnel (Figures 1 and 2) led to retrospective SARS diagnoses in deceased patients (patients 4, 10, and 14), which then led to quarantine of 15 morgue workers. One morgue worker (patient 41) who had handled the remains of patients

with initially unrecognized SARS (patients 4 and 18) eventually developed and died of SARS.

Outbreak of SARS Among Family Members and Caretakers of Patients

In total, 19 family members of persons with SARS were involved in this SARS epidemic (Figure 2). Family members of patients 14 and 19 were found to have epidemiologic links to 2 caretakers (patient 34 [a caretaker from the family] and patient 17 [a paid caretaker], respectively). Fever was detected in 1 female semiprofessional caretaker (patient 13) when she was admitted to CGMH-KS. This woman had sought a job in the hospital and was exposed to patient 3; she was therefore placed in isolation and subsequently received a diagnosis of SARS on the basis of chest radiograph and polymerase chain reaction findings. Patient 33, who had received incomplete treatment for chronic obstructive pulmonary disease with acute exacerbation, insisted on leaving the hospital on May 7, 2003, and was admitted to a local hospital in his hometown for further treatment; both his wife (patient 42) and a paid caretaker (patient 53) of the patient staying in the neighboring bed of the local hospital were infected with SARS coronavirus.

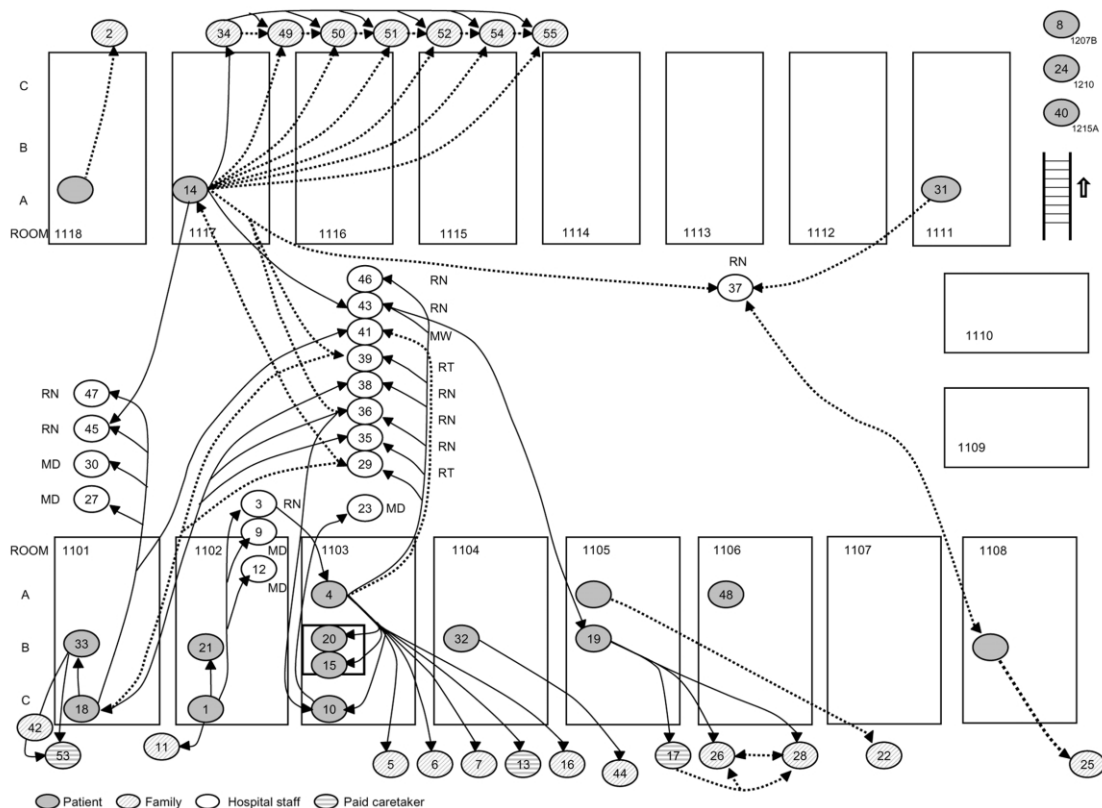


FIGURE 2. Diagram of the cluster of cases of severe acute respiratory syndrome (SARS) in ward 11A at Chang Gung Memorial Hospital (Kaohsiung, Taiwan), showing the spatial distribution and the possible epidemiologic links between persons who acquired SARS during the nosocomial outbreak. MD = clinician; MW = morgue worker; RN = nurse; RT = respiratory therapist.

TABLE 2. Characteristics of the Originally Hospitalized Patients With Initially Unrecognized Superimposed Severe Acute Respiratory Syndrome (SARS)

Patient number	Age; sex	Room and bed number	Date of symptom onset, mo/d/y		Outcome, mo/d/y	Other patients with an epidemiologic link ^c	Detailed description
			Initial ^a	Secondary ^b			
4	82; F	1103A	4/8/03	5/2/03	Died 5/8/03	3, 5, 6, 7, 10, 13, 15, 16, 20, 29, 35, 36, 38, 39, 41, 43, 46	Underlying bronchiectasis and steroid use. Maximal temperature of 37.7°C. Admitted because of bacterial pneumonia; leukocytosis was noted 1 week before death.
10	58; F	1103C	4/8/03	5/4/03	Died 5/5/03	4, 23, 36	Underlying mesothelioma with massive pleural effusion. Admitted because of bacterial pneumonia; leukocytosis was noted 4 days before death.
14	78; M	1117A	4/29/03	5/6/03	Died 5/9/03	29, 34 , 36, 37, 39, 43 , 45, 49, 50, 51, 52, 54, 55	Underlying COPD. Admitted because of bacterial pneumonia and GI bleeding.
18	55; M	1101C	4/14/03	5/7/03	Died 5/9/03	27, 29, 30, 33, 35, 36, 38, 39, 41, 45, 47	Underlying lung cancer. Admitted due to bacterial pneumonia; leukocytosis was noted 4 days before death.

NOTE. COPD = chronic obstructive pulmonary disease; GI = gastrointestinal.

^a The first date that the patient experienced high fever and respiratory symptoms. Because many of the patients had other medical problems leading to hospital admission, this initial onset date is not necessarily the onset of SARS coronavirus infection. For such patients, there may have been a period of recovery (ie, return to normal temperature and resolution of respiratory signs and symptoms) followed by a recurrence of high fever and deterioration of respiratory function.

^b The date on which the second clinical deterioration indicative of onset of SARS illness among nosocomially infected patients. The exact date of onset of superimposing SARS in case 10 was not clear because of persistent fever due to bacterial pneumonia, and therefore the fifth day after exposure to the infection source (ie, the mean incubation duration of SARS in this series) was estimated as the SARS onset date.

^c Patients with strong epidemiologic links are in bold font, and weak links are in normal font. Strong epidemiologic links include known exposure to SARS during a high-risk procedure (eg, intubation) or other close contact (eg, with a roommate or caretaker). Weak epidemiologic links include limited exposure (eg, routine nursing care involving multiple patients). All patients with at least 1 temporal and 1 physical epidemiologic link are listed.

Initial and Subsequent Infection Control Measures Used

On April 30, 2003, after the diagnosis of presumed SARS was made for the index patient in room 1102 on the basis of her epidemiologic history of exposure, hospital staff isolated the index patient and the 2 patients occupying the neighboring beds in 3 separate negative-pressure rooms. Isolation procedures were identical to those used elsewhere.⁶ All medical personnel who had been exposed to room 1102 were notified to immediately don N95 respirators, and 48 hospital personnel were quarantined in a separate building. All patients and caretakers in ward 11A were asked to comply with on-site quarantine procedures. Eight patients, however, insisted on leaving the hospital immediately. This presumed SARS outbreak, coupled with a compiled list of patients (including those who left against medical advice) and their family members, was immediately reported to the government health department. All patients staying in ward 11A were discharged home for a 2-week quarantine period only after their clinical status improved.

A team composed of chest physicians was formed on May 1 to screen all patients in the chest ward for possible SARS by reviewing medical charts, reading chest radiographs, and monitoring clinical signs and symptoms suggestive of SARS. Because of the continuous emergence of SARS cases, ward

11A and the wards located immediately above and below (wards 10A and 12A) were closed on May 11. Construction of 15 additional standard negative-pressure isolation rooms was expedited in ward 13A. Ward 12A was then vacated so that simple negative-pressure isolation rooms could be created by installing window-mounted exhaust fans to generate negative pressure. On May 16, the hospital grouped patients by SARS classification: patients with a diagnosis of probable SARS were housed in the standard negative-pressure rooms in ward 13A, whereas patients identified as having suspected SARS were placed in the simple isolation rooms in ward 12A.

From early May 2003, the SARS epidemic in southern Taiwan caused mass panic in the community and among medical professionals. Therefore, almost all hospitals in this area refused to admit febrile patients and patients with a history of recent exposure to SARS-affected hospitals. CGMH-KS closed its outpatient clinics on May 16 and moved its emergency department to temporary quarters outside, triaging and limiting its service to patients who had been released from this hospital since April 26, patients with a suspicion of community-acquired SARS, and patients with severe illness that mandated treatment at a medical center. Medical personnel caring for patients with fever donned full personal protective equipment. Healthcare worker access restrictions and adher-

ence to hand hygiene were strictly enforced under the supervision of recruited staff members. A dedicated transportation path through CGMH-KS for patients with SARS was created, and the pathway was disinfected after each patient was transported. Upon encountering a new patient, the admitting clinician in the emergency department or the wards had to complete a checklist regarding epidemiologic exposure, chest radiograph findings, clinical manifestations, and laboratory data suggestive of SARS, to determine whether a consultation with a chest or infectious diseases physician was needed.

By mid-May, there were approximately 300 patients with a chronic or critical clinical condition staying in CGMH-KS (approximately 2,200 patients per day were staying in CGMH-KS before this SARS outbreak). The last SARS case that was epidemiologically linked to this outbreak and occurred outside the hospital was documented in a young man (case 55) on May 25, whereas the last SARS cases that developed in the hospital were documented in 2 nurses (cases 46 and 47) on May 17, indicating successful containment of this nosocomial outbreak of SARS.

DISCUSSION

A SARS outbreak in a municipal hospital during March 2003 in Taipei resulted in the abrupt closure of that hospital coupled with on-site quarantine of patients, visitors, and health-care workers.² This caused mass panic in Taiwan. The constant warnings issued by the health authorities and widely publicized by the news media that there was a high risk of contracting and transmitting SARS after exposure to affected hospitals stigmatized many people. This is the likely reason that the index patient in this nosocomial outbreak denied her recent visit to the SARS-affected hospital in Taipei. Unfortunately, this patient was hospitalized without the hospital's knowledge that she had SARS, which eventually led to a disaster in CGMH-KS and the surrounding community.

Until vaccination against SARS becomes effectively applicable, isolation of infectious patients and quarantine of the potentially infected contacts are important measures to prevent the rapid spread of SARS,⁶ especially in a densely populated hospital setting with continuous therapeutic and nursing contacts between patients and medical personnel. Effective implementation of large-scale quarantine measures to prevent spread of a highly contagious disease requires an effective partnership between health authorities and the public,⁷ which only can be built on mutual understanding of the potential catastrophic consequences if the communicable disease is uncontrolled. Enforced on-site quarantine at the very beginning of this nosocomial outbreak of SARS might have aroused mass panic among the quarantined people and their families and caused further transmission from the patients with SARS to those not yet infected but crowded in the same ward. Because CGMH-KS lacked legal authority to enforce an on-site quarantine and, on the basis of the earlier experience

of abrupt on-site quarantine in a SARS-affected hospital in Taipei,² anticipated panic among the patients and medical staff, the reasonable option for CGMH-KS was to isolate the index patient and the neighboring patients, review their clinical courses, closely monitor the potentially infected patients in the ward for emergence of clinical evidence of SARS, and treat all of these patients in accordance with established guidelines. Unfortunately, these measures did not work. Atypical clinical manifestations of SARS, which are not uncommonly encountered in hosts with comorbidities and/or underlying immunocompromise, make recognition of SARS difficult for medical professionals inexperienced with this newly emerging disease.⁸⁻¹² In this series of patients, a body temperature of less than 38°C, which failed to meet the WHO criteria for SARS, was observed in 1 patient (patient 4); leukocytosis, instead of a normal peripheral white cell count or leukopenia, which have been reported in a large number of patients with SARS,^{13,14} was documented in 3 patients (patients 4, 10, and 18). The finding of additional consolidation on chest radiographs of these vulnerable patients with copious purulent respiratory excretion was more consistent with nosocomial bacterial pneumonia. Failure to detect SARS early in immunocompromised patients with atypical clinical manifestations results in the spread of SARS by these patients in the hospital, thus enlarging the epidemic and potentially making its control intractable.^{10,11}

An earlier community SARS outbreak in Hong Kong suggested that SARS coronavirus could be spread in air currents.¹⁵ On the basis of this hypothesis, which was formed amid the uncertainty of SARS epidemics, patients with SARS were treated and isolated in either standard negative-pressure rooms or makeshift negative-pressure rooms^{2,11,16,17}; whereas in countries with limited resources, patients with SARS were treated in rooms open to outside air circulation.¹⁶ There has been no well-designed experimental or epidemiologic study so far that supports the requirement to isolate patients with SARS in negative-pressure rooms.¹⁸ It is noteworthy that no healthcare worker caring for patients in whom SARS had been diagnosed in this nosocomial epidemic was infected by SARS coronavirus. Thus, the most important factor in containment of an outbreak is a timely identification of patients with SARS. However, given the limitations of SARS testing,^{19,20} possible loss of information on epidemiologic links, and the nonspecific clinical presentations in hospitalized patients, it is very important to establish cohorts of persons with low, medium, and high likelihoods of SARS acquisition.

The infection control measures in CGMH-KS proved to be effective, because nosocomial transmission of SARS was terminated after May 17. As mentioned in Results, most hospitals in southern Taiwan were unwilling to admit febrile patients during the SARS epidemic. Therefore, with the exception of 1 patient (patient 33), no patients released from our hospital caused nosocomial SARS outbreaks in other hospitals. Clusters of SARS cases involving a number of families in this outbreak were found to have been transmitted by the

patients' caretakers. This implies that both family and hired caretakers in countries whose care systems rely on such caregivers should be included in formal infection control plans and should receive standardized training and equipment.

Failure to detect SARS in a hospitalized patient in a timely fashion can paralyze a large medical center to a degree that was unimaginable before the SARS epidemic.^{11,13} The public panic, the economic impact, and the cost of depriving medical resources to local residents in this SARS epidemic are difficult to assess, but they must be enormous. The resurgence of SARS is possible, considering its uncertain origin and the existence of a likely animal reservoir (the palm civet cat and bats).^{21,22} Given the potential disastrous consequences, the importance of preparedness for the unpredictable reoccurrence of a SARS epidemic cannot be overemphasized. A dedicated hospital for treatment of patients with SARS should also be considered necessary in the containment of a SARS epidemic, because most transmissions of SARS have occurred in hospitals.^{2,10,11,13,23} Although rapid closure of the SARS-affected ward for cohorting patient care is effective in containment of the spread of infection, it would be ideal to transfer the affected patients to a dedicated SARS hospital, if one is available. All of these strategies can be effectively implemented only when the health authorities and the public are well prepared.

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REFERENCES

1. Twu SJ, Chen TJ, Chen CJ, et al. Control measures for severe acute respiratory syndrome (SARS) in Taiwan. *Emerg Infect Dis* 2003; 9:718-720.
2. Lee ML, Chen CJ, Su IJ, et al. Severe acute respiratory syndrome—Taiwan, 2003. *MMWR Morb Mortal Wkly Rep* 2003; 52:461-466.
3. World Health Organization (WHO). Case definitions for surveillance of severe acute respiratory syndrome (SARS). Geneva, Switzerland: WHO; 2003.
4. Fouchier RAM, Kuiken T, Schutten M, et al. Kock's postulates fulfilled for SARS virus. *Nature* 2003; 423.
5. World Health Organization (WHO). Hospital infection control guidance for severe acute respiratory syndrome (SARS). Geneva, Switzerland: WHO; 2003.
6. Centers for Disease Control and Prevention. Public health guidance for community-level preparedness and response to severe acute respiratory syndrome (SARS) version 2. Supplement D: Community containment measures, including non-hospital isolation quarantine. Available at: <http://www.cdc.gov/ncidod/sars/guidance/D/lessons.htm>. Accessed November 22, 2004.
7. Meltzer MI, Damon I, LeDuc JW, Millar JD. Modeling potential responses to smallpox as a bioterrorist weapon. *Emerg Infect Dis* 2001; 7:959-969.
8. Tee AK, Oh HM, Lien CT, Narendran K, Heng BH, Ling AE. Atypical SARS in geriatric patient. *Emerg Infect Dis* 2004; 10:261-264.
9. Tan TT, Tan BH, Kurup A, et al. Atypical SARS and *Escherichia coli* bacteremia. *Emerg Infect Dis* 2004; 10:349-352.
10. Gopalakrishna G, Choo P, Leo YS, et al. SARS transmission and hospital containment. *Emerg Infect Dis* 2004; 10:389-394.
11. McDonald LC, Simor AE, Su IJ, et al. SARS in healthcare facilities, Toronto and Taiwan. *Emerg Infect Dis* 2004; 10:777-781.
12. Lam MF, Ooi GC, Lam B, et al. An indolent case with severe acute respiratory syndrome. *Am J Respir Crit Care Med* 2004; 169:125-128.
13. Lee N, Hui D, Wu A, et al. A major outbreak of severe acute respiratory syndrome in Hong Kong. *N Engl J Med* 2003; 348:1986-1994.
14. Booth CM, Matukas LM, Tomlinson GA, et al. Clinical features and short-term outcomes of 144 patients with SARS in the greater Toronto area. *JAMA* 2003; 289:2801-2809.
15. Hong Kong Department of Health Report. Main findings of an investigation into the outbreak of severe respiratory syndrome at Amoy Gardens. Available at: <http://www.info.gov.hk/dh/ap.htm>. Accessed April 19, 2003.
16. Lee NE, Sitarayapon P, Tappero J, et al. Infection control practice for SARS in Lao People's Democratic Republic, Taiwan, and Thailand: experience from mobile SARS containment teams, 2003. *Am J Infect Control* 2004; 32:377-383.
17. Fung CP, Hsieh TL, Tan KH, et al. Rapid creation of a temporary isolation ward for patients with severe acute respiratory syndrome in Taiwan. *Infect Control Hosp Epidemiol* 2004; 25:1026-1032.
18. Centers for Disease Control and Prevention. Public health guidance for community-level preparedness and response to severe acute respiratory syndrome (SARS). Supplement C: preparedness and response in health facilities. Available at: <http://www.cdc.gov/ncidod/sars/guidance/C/index.htm>. Accessed May 30, 2004.
19. Peiris JSM, Chu CM, Cheng VCC, et al. Clinical progression and viral load in a community outbreak of coronavirus-associated SARS pneumonia: a prospective study. *Lancet* 2003; 361:1767-1772.
20. Hsueh PR, Hsiao CH, Yeh SH, et al. Microbiologic characteristics, serologic response, and clinical manifestations in severe acute respiratory syndrome, Taiwan. *Emerg Infect Dis* 2003; 9:1163-1167.
21. Guan Y, Zheng BJ, He YQ, et al. Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. *Science* 2003; 302:276-278.
22. Li W, Shi Z, Yu M, et al. Bats are natural reservoirs of SARS-like coronaviruses. *Science* 2005; 310:676-679.
23. Riley S, Fraser C, Donnelly CA, et al. Transmission dynamics of the etiological agents of SARS in Hong Kong: impact of public health interventions. *Science* 2003; 300:1961-1966.