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# Using an integrated infection control strategy during outbreak control to minimize nosocomial infection of severe acute respiratory syndrome among healthcare workers

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**Summary** Healthcare workers (HCWs) are at risk of acquiring severe acute respiratory syndrome (SARS) while caring for SARS patients. Personal protective equipment and negative pressure isolation rooms (NPIRs) have not been completely successful in protecting HCWs. We introduced an innovative, integrated infection control strategy involving triaging patients using barriers, zones of risk, and extensive installation of alcohol dispensers for glove-on hand rubbing. This integrated infection control approach was implemented at a SARS designated hospital ('study hospital') where NPIRs were not available. The number of HCWs who contracted SARS in the study hospital was compared with the number of HCWs who contracted SARS in 86 Taiwan hospitals that did not use the integrated infection control strategy.

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Two HCWs contracted SARS in the study hospital (0.03 cases/bed) compared with 93 HCWs in the other hospitals (0.13 cases/bed) during the same three-week period. Our strategy appeared to be effective in reducing the incidence of HCWs contracting SARS. The advantages included rapid implementation without NPIRs, flexibility to transfer patients, and re-inforcement for HCWs to comply with infection control procedures, especially handwashing. The efficacy and low cost are major advantages, especially in countries with large populations at risk and fewer economic resources.

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## Introduction

Severe acute respiratory syndrome (SARS) has claimed 73 lives in Taiwan including two first year resident physicians and five critical care nurses. The initial SARS epidemic among healthcare workers (HCWs) in Taiwan started at the Taipei Municipal Hoping Hospital (TMHH). Seventeen HCWs contracted SARS between 22 and 23 April 2003 from six different locations within the hospital; interestingly, none of the 17 HCWs had known direct contact with the index SARS patients admitted from the community.<sup>1</sup> Health officials decided to quarantine the hospital because it was postulated that Taiwan SARS cases involving HCWs were occurring as a result of nosocomial transmission. More than 1000 patients, HCWs and visitors were not allowed to leave the TMHH for three days. Subsequently, the President of Taiwan made an executive decision on 26 April 2003 to evacuate the hospital. Within 48 h, renovation of a military hospital was completed to accommodate transfer of the SARS patients from TMHH to the study hospital.

Ultimately, 150 individuals contracted SARS from one index case admitted to TMHH, including 113 patients and 37 HCWs.<sup>2</sup> To protect our HCWs and non-infected patients from contracting SARS, we introduced a new approach that we have named the 'integrated infection control strategy'. We assessed the effectiveness of the integrated infection control strategy by comparing the rate of SARS transmission in HCWs in the study hospital with that in other major hospitals in Taiwan without the integrated infection control strategy.

## Methods

### Description of the study hospital

The study was conducted between 27 April and 21 May 2003 in a 67-bed military hospital, with four

stories in a single building. For the purposes of this article, we refer to this hospital as the study hospital. The first floor is an admission office that has a special designated pathway which leads directly to the elevator. The second floor is restricted to patients that are ready to be discharged. The third floor is the designated ward for suspect cases, and the fourth floor is designated for probable or confirmed cases. Patients who advanced from suspect to probable cases were moved from the third to the fourth floor and vice versa.

Negative pressure isolation rooms (NPIRs) were not available in the study hospital given the urgency of the initial situation. A 'negative-pressure-like' environment was created in the study hospital as follows. All windows of the rooms facing due east (next to a residential building) were sealed air tight. All gaps at the bottom of the doors of patients' rooms (one patient per room) were sealed. Sixteen-inch exhaust fans were installed in patients' rooms facing due west to create a negative-pressure-like airflow within the rooms. The exits and staircases of each floor were sealed to prevent air interflow between floors. Four separate central air conditioning systems provided ducted air for each floor. Each ventilation system was set up to use a mixture of 50% fresh air taken from the outside and, as an economy measure, 50% air extracted from all areas of the hospital building within the same floor. All of the exhaust air to the west was blown outside to a 60×30 m restricted area, and N95 respirators were required for all personnel who entered this area. This approach was inspected by US Centers for Disease Control and Prevention (CDC) personnel and approved by the Taiwan Department of Health.

During the study period, 193 suspect and probable SARS cases were admitted to the study hospital. Eighty-five medical doctors (708 person×day), 203 nurses (1768 person×day) and 171

administrative personnel and volunteers (1341 person×day) were clinically evaluated for SARS in the study hospital. For each HCW, body temperature was monitored twice a day and clinical symptoms of fever greater than 38 °C, cough, shortness of breath, difficulty breathing or hypoxia were evaluated. Those HCWs who acquired nosocomial SARS infection in the comparison hospitals were also evaluated for their history of contact, clinical symptoms and laboratory confirmation for SARS.

### Case definition

The SARS case definition was based on clinical, epidemiological and laboratory criteria published previously.<sup>3,4</sup> In this study, we mainly used World Health Organization (WHO) case definitions.<sup>3</sup> A suspect case was defined as an epidemiologically confirmed patient who met the clinical criteria of moderate respiratory illness.<sup>3</sup> A probable case was defined as a patient who met the criteria for a suspect case with severe respiratory illness (e.g. pneumonia or respiratory distress syndrome).<sup>3</sup>

### Baseline protection for HCWs

All HCWs received mandatory SARS prevention training, which included the use of personal protective equipment (PPE) as mandated by the Department of Health, Taiwan. PPE included an N95 respirator, eye protection, gown, mask and latex gloves as recommended by the WHO.<sup>5</sup> In addition to PPE, most HCWs used a disposable second layer of protective clothing (outer gloves, gown, head and foot covering).<sup>6</sup>

### Integrated infection control strategy

The integrated infection control strategy is an integrated system that consists of the aforementioned standard infection control policy<sup>6</sup> in addition to 'traffic control' with the following components.

#### Traffic into hospital

A 'triage and dispatch' station was located outside the hospitals. When a patient was admitted with a fever above 38 °C or a preliminary diagnosis of SARS was made, the patient was transported via a designated elevator; hospital personnel and volunteer use of this elevator was prohibited. The path to the elevator was isolated with double curtains to provide separate pathways for patients and HCWs. The floors were marked with coloured paint or duct tape for guidance of patients and HCWs. After the

patient reached their room, a decontamination team disinfected the pathway including the floor and elevator wall with a hypochlorite solution containing c. 5 ppm free chlorine.

### Zones of risk

The hospital space was separated into three zones (contaminated, intermediate and clean) based on the potential risk of SARS transmission. The third and fourth floors where SARS cases were contained were defined as contaminated zones. The hallways to the third and fourth floors were defined as intermediate zones. The nurses' preparation station and medical offices in the first floor were defined as clean zones. A separate entrance/exit for HCWs to enter/leave the ward was designated to avoid crossing or overlapping with patients in the contamination zone.

For patient visits, HCWs wore standard PPE including an N95 respirator in the nurses' preparation station, checked the gear and the fit of the respirator, walked past the hallways (intermediate zone), and entered the ward and the patient's room (contamination zone). Upon leaving patients' rooms, HCWs were required to go through the intermediate zones for 'stepdown' removal of outer gowns and handwashing with 75% alcohol before entering the nurses' preparation station. In case of accidental contamination in the intermediate zone (e.g. patient coughing on the floor), a decontamination team disinfected the area with a hypochlorite solution containing c. 5 ppm free chlorine. Each zone was clearly designated by wooden/plastic barriers to avoid casual breakthrough by anyone passing from contaminated zones into clean zones. Master copies of patients' charts were kept in the clean zone, and a facsimile machine was used to transmit copies of patients' charts to the nurses' preparation station for record keeping. Verbal communication between HCWs in the ward and the medical office was made by videophone.

### Extensive installation of alcohol dispensers for glove-on hand rubbing

Seventy-five percent alcohol dispensers were installed in each zone throughout the hospital, i.e. outside every door, inside every patient's room, by the switch of every elevator, and at the nurses' station. Before entering/leaving each patient's room, healthcare workers were required to disinfect their hands by rubbing (while wearing double latex gloves) with 75% alcohol solution to prevent any contact transmission from the gloves to the doorknob or other surfaces. After entering/leaving the room and closing the door,

their hands were disinfected again. This 'disinfect-touch-disinfect' routine was applicable in all zones.

### Description of comparison hospitals

Eighty-six hospitals were used as comparison hospitals with a total of 746 NPIR beds, caring for SARS patients without the integrated infection control strategy.<sup>6</sup> All HCWs in this group were trained properly before the SARS epidemic in Taiwan through a national regulation for a standard nosocomial infection control programme, with infectious diseases physicians/infection control nurses available in each regional and tertiary hospital. After the first SARS case was detected in Taiwan, the health authorities audited and implemented strict infection control practices for those hospitals. HCWs received education and training regarding SARS, and were trained in the use of PPE as mentioned above.<sup>6</sup> However, no triage was implemented on admission into hospital, zones of risk were not established and handwashing dispensers were not systemically installed.

### Results

During the study period, only two HCWs (both nurses) in the study hospital developed fever ( $> 38^{\circ}\text{C}$ ), cough and infiltrative lesions on chest radiograph. The polymerase chain reaction result for SARS-CoV was positive for both nurses. There were 43 suspected and 50 probable SARS cases in HCWs from 86 comparison hospitals during the three-week study period. The number of HCWs who contracted SARS in the study hospital was significantly lower than that in the comparison hospitals (0.03 cases/bed vs 0.13 cases/bed, respectively,  $P=0.03$ ).

### Discussion

In non-epidemic areas of the world without SARS, HCWs may be the primary victims of SARS.<sup>7</sup> The use of PPE and NPIRs are the standard operating procedures. However, despite these recommendations, nosocomial SARS infections among HCWs still occurred.<sup>8-10</sup> Thus, we placed priority on protecting HCWs from contracting the infection from a few index cases who are hospitalized, and then spreading the infection to other patients and HCWs, who then introduce SARS into the community. The efficacy of PPE and NPIRs appeared to be unsatisfactory in Taiwan<sup>6</sup> and this was also reported

in Canada.<sup>10,11</sup> We devised a new integrated strategy to minimize transmission. This was an integration of standard infection control procedures and traffic control, consisting of patient traffic into hospital, zone of risks and extensive installation of alcohol dispensers for glove-on hand rubbing.

Our study suggests that suspect SARS cases may not need to be housed in standard NPIRs for their entire stay if their clinical condition improves, as manifest by lack of respiratory distress, intubation not required and stable lung infiltrate; presumably, the viral load has decreased such that transmission no longer occurs.<sup>12,13</sup> Patients who are stable may be placed in regular 'stepdown wards' (with minor renovations) when the integrated infection control strategy is applied.

This approach can be applied in facilities that do not have NPIRs. In many hospitals, SARS patients with atypical manifestation may be admitted, and a nosocomial outbreak may quickly ensue in their facilities. Under such circumstances, rapid implementation of preventive measures may be a crucial factor in minimizing transmission and buying time of two to three weeks to establish a dedicated SARS hospital with NPIRs.

Although the importance of handwashing in controlling nosocomial infection has been well established, an average compliance rate of 30% has always been a problem in the real world.<sup>14,15</sup> Despite the widely accepted recommendation of wearing gloves as the primary measure of barrier precautions, this does not outweigh the importance of handwashing.<sup>16,17</sup> We speculated that a possible perceived lack of need by HCWs to wash hands if gloved may have resulted in the transmission of SARS by direct/indirect casual contact.<sup>13</sup> Inefficient clean/dirty area distinction may further increase nosocomial transmission. In a limited six-hospital survey, the circumstantial evidence showed that two SARS-affected hospitals that did not separate the patient transporting route and the isolation ward were epidemiologically linked to transported SARS patients.<sup>18</sup> The strategic installation of alcohol dispensers to enforce hand disinfection between zones of risk is an important aspect of the integrated infection control strategy. We facilitate this standard precaution to increase awareness and vigilant adherence to routine handwashing when working between zones of risk to minimize SARS transmission.

The integrated infection control strategy may be most useful in countries where SARS cases are limited or non-endemic. The integrated infection control strategy may curtail epidemic nosocomial spread because it can be implemented rapidly at

relatively low cost. However, the integrated infection control strategy can also be useful to countries with epidemic SARS and limited healthcare resources. NPIRs can be used selectively for patients who are most severely ill and most likely to spread the virus.<sup>13</sup> For those hospitals without NPIRs and housing patients who are less severely ill or recovering, the integrated infection control strategy could be implemented.

The major weakness of our conclusion is that the study hospital and 86 comparison hospitals were not strictly comparable. For example, NPIRs were not available in the study hospital, while 746 beds were in NPIRs in the comparison hospitals. Analysis of HCW cases could not be stratified by the severity of illness and degree of infectivity for the index cases since such criteria have not been standardized. So, a prospective randomized study comparing the application of the integrated infection control strategy with the standard approach would have been the most rigorous method to confirm the efficacy of the integrated infection control strategy. However, this ideal method was impossible to implement during an outbreak. Between 27 April and 21 May 2003, only two HCWs contracted SARS from the study hospital. Given this significant difference ( $P=0.033$ ) and the fact that the study hospital had the highest proportion of SARS patients in Taiwan and not a single NPIR, the Taiwan CDC mandated that all Taiwan hospitals with SARS patients should immediately adopt the integrated infection control strategy after 21 May 2003 and the SARS epidemic was under control in two weeks. It may be possible to evaluate this approach in a controlled fashion to confirm its effectiveness in other countries. If confirmed, the integrated infection control strategy may be a model of infection control for epidemic infectious diseases of the future.

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